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Ground Cloud Dispersion Measurements During The Titan IV Mission #K24 (23 February 1997) at Cape Canaveral Air Station

Volume 1—Test Overview and Data Summary

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SMC/CLNE

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13. ABSTRACT (*Maximum 200 words*)

Launch plume visible and infrared imagery were accomplished during the launch of Titan IV Mission #K24 at Cape Canaveral Air Station on 23 February 1997. These data will be used to improve the accuracy of the Rocket Exhaust Effluent Diffusion Model (REEDM). The imagery from four sites measured a cloud stabilization height of 803 m AGL compared to a REEDM-predicted stabilization height at 920 m AGL. This height was reached in 2.75 to 3.75 min compared to a REEDM prediction of 3.89 min. The imagery-derived cloud trajectory was 76° compared to the 300° trajectory predicted by REEDM. Measurements of aerial and ground-level concentrations of hydrogen chloride (HCl) were not taken during this launch.

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Preface

The Air Force Space and Missile Systems Center's Launch Programs Office (SMC/CL) is sponsoring the Atmospheric Dispersion Model Validation Program (MVP). This program is collecting launch cloud dispersion data that will be used to determine the accuracy of atmospheric dispersion models, such as REEDM, in predicting toxic hazard corridors at the launch ranges. This report presents launch cloud dispersion and meteorological measurements performed during the #K24 Titan IV launch at Cape Canaveral Air Station on 23 February 1997.

An MVP Integrated Product Team (IPT), led by Capt Brian Laine (SMC/CLNM), is directing the MVP effort. Dr. Bart Lundblad of The Aerospace Corporation's Environmental Systems Directorate (ESD) is the MVP technical manager. This report was prepared by Mr. Norman Keegan (ESD) and Dr. Lundblad from materials contributed by personnel participating in the #K24 launch cloud dispersion measurements.

Visible and infrared imagery measurements were made of the launch cloud by Dr. Robert Abernathy, Ms. Karen Foster, Ms. Janet Webb, Mr. Gary Harper, Mr. Brian Kasper, Mr. Jess Valero, and Mr. Tom Knudtson of The Aerospace Corporation's Environmental Monitoring and Technology Department (EMTD). Field assistance was provided by Mr. Noble Dowling. Mr. Doug Schulthess of Aerospace's Eastern Range Directorate coordinated site selection and logistical support with Range organizations. Ms. Foster digitized the imagery data for analysis by Dr. Abernathy. The description of the cloud imagery results was prepared by Dr. Abernathy.

Ground and aerial HCl measurements were not conducted during this launch.

The #K24 mission was the tenth Titan IV launch for which usable launch cloud dispersion data were collected by MVP. The previous missions were #K7, #K23, #K19, #K21, #K15, #K16, #K2, #K22, and #K13.

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Executive Summary

This report presents plume imagery documenting the development and dispersion of the Titan IV #K24 launch ground cloud at Cape Canaveral Air Station (CCAS). It is significant to note that this launch was the first launch of a Titan IV utilizing the larger Solid Rocket Motor Upgrade (SRMU) as Stage Zero. The launch took place on 23 February 1997 at 2020 Zulu time. The report also presents pertinent meteorological data taken from towers and rawinsonde balloons.

The imaging team successfully tracked the trajectory and time evolution of the vehicle's exhaust ground cloud for 6 min following launch using four infrared and visible light camera systems.

Meteorological data were collected to improve understanding of cloud dispersion and to use as input during model simulations and evaluations. Rawinsonde balloon data from shortly before launch and meteorological tower data from shortly before and after launch were collected and archived. These data and similar data on other Titan IV launches (past and future) will be used to determine the accuracy of atmospheric dispersion models such as the Rocket Exhaust Effluent Diffusion Model (REEDM) in predicting toxic hazard corridors (THCs) at the USAF Eastern and Western Ranges. These THCs assess the risk of exposing the public to HCl exhaust from solid rocket motors or hypergolic propellant vapors accidentally released during launch operations.

Reduction of imagery data from the first 6 min following launch yielded the stabilization height, rise time, ground track, and speed of the ground cloud. Comparison to REEDM 7.08 predictions show that the imagery-derived stabilization height (803 m) is lower than the height predicted by REEDM (920 m), and that the imagery-derived time to stabilization (2.75 to 3.75 min) is faster than the REEDM-predicted stabilization time of 3.89 min. The imagery-derived cloud trajectory was 76° compared to the 300° trajectory predicted by REEDM. The imagery-derived velocity of the cloud (5 to 9 m/s) is up to 119% greater than the rawinsonde wind measurement (4.1 m/s) and 157% greater than the velocity predicted by REEDM (3.5 m/s).

1. Introduction

Launch vehicles that employ solid-propellant rocket motors release exhaust ground clouds containing large quantities of hydrogen chloride (HCl) into the launch areas at Cape Canaveral Air Station (CCAS) and Vandenberg Air Force Base (VAFB). Large quantities of hazardous liquid fuels and oxidizers could also be released as a result of propellant transfer accidents or launch vehicle failures. The Air Force uses atmospheric dispersion models to predict the downwind diffusion and concentration of toxic launch clouds. There exists a strong need to collect launch cloud data that can be used to test and validate the performance of these dispersion models.

The Air Force range safety organizations at Patrick Air Force Base (45 SW/SE) and VAFB (30 SW/SE) are responsible for assuring that launches are occur only when meteorological conditions will not expose nearby public areas to hazardous levels of launch exhausts and propellant vapors. Predictions of toxic hazard corridors that extend into public areas can lead to costly launch delays. The present use of non-validated models requires the use of conservative launch criteria. The development and validation of accurate atmospheric dispersion models is expected to increase launch opportunities and significantly reduce launch costs. The Space and Missile Systems Center's Launch Programs Office (SMC/CL) established the Atmospheric Dispersion Model Validation Program (MVP) to collect launch cloud data and to use the data to test and validate current and future atmospheric dispersion models at the ranges.

The MVP effort involves the collection of data during Titan IV launches at CCAS and VAFB to characterize HCl launch cloud rise, growth, and stabilization, as well as launch cloud transport and diffusion. These data, along with data collected during tracer gas releases, will be used to determine the capability of the Rocket Exhaust Effluent Diffusion Model (REEDM) for predicting toxic hazard corridors at the ranges. REEDM is used at CCAS and VAFB to predict the locations of toxic hazard corridors in support of launch operations. It is applied to large heated sources of toxic air emissions such as nominal launches, catastrophic failure fireballs, and inadvertent ignitions of solid rocket motors. It uses launch vehicle and meteorological data to generate ground-level concentration isopleths of HCl, hydrazine fuels, nitrogen dioxide, and other toxic launch emissions. Launch holds may occur when REEDM toxic concentration predictions exceed adopted exposure standards. REEDM is a unique and complex model based on relatively simple modeling physics. It has a long development history with the Air Force and NASA, but has never been fully validated. Validation of REEDM has been identified as a range safety priority.

The MVP has been organized and is being directed by the MVP Integrated Product Team (IPT). SMC/CL is serving as the IPT leader, while The Aerospace Corporation's Environmental Systems Directorate serves as the IPT technical manager. The IPT consists of personnel with expertise in atmospheric dispersion modeling, meteorology, and atmospheric dispersion field studies. MVP participants include personnel from SMC, 30 SW, 45 SW, Armstrong Laboratory, The Aerospace Corporation, NASA, NOAA, and contractors. Key functions include program planning, field data collection, data review and compilation, range coordination, and model validation.

This report presents the results of measurements performed at CCAS during the Titan IV #K24 launch on 23 February 1997. This was the first launch to employ the larger solid rocket motors called the Solid Rocket Motor Upgrade (SRMUs). Visible and infrared measurements were made on the ground cloud to monitor its growth, stabilization, and trajectory. The imagery results are presented in Section 2. REEDM 7.08 predictions of ground cloud stabilization heights and surface concentrations are presented in Appendix A. REEDM 7.08 includes revised exhaust values for Titan SRMU launches. Measurements of meteorological data are tabulated in Appendix B. The imagery results presented in this, as well as other MVP reports, will allow the accuracy of REEDM and other launch range atmospheric dispersion models to be determined over the range of possible meteorological conditions.

2. Imagery of the Titan IV #K24 Ground Cloud

[The material in this section was contributed by R. N. Abernathy, J. Y. Webb, K. L. Foster, and B. P. Kasper of the Environmental Monitoring and Technology Department of The Aerospace Corporation's Space and Environment Technology Center.]

2.1 Background

On 23 February 1997, the Titan IVB #K24 mission was successfully launched from Space Launch Complex 40 (SLC-40) at Cape Canaveral Air Station (CCAS) at 1520 EST (2020 GMT). This section describes the quantitative exhaust cloud imagery data collected by each of four imagery sites during the 6 min immediately following the launch from SLC-40. This section also describes the data acquisition hardware and analysis software. The two-dimensional cloud images obtained by the various imagery sites were combined in a pair-wise fashion to produce stereoscopic 3-D information. This analysis yielded the cloud's rise time, stabilization height, speed, and bearing.

The quantitative imagery-derived ground cloud data are reported here in several graphical formats to facilitate comparison with REEDM predictions (Appendix A) and rawinsonde sounding data (Appendix B). For clarity, this section includes some data from the appendices. It is apparent from review of this section that these data are useful for validating current and future dispersion models.

The purpose of this report was to document the quality and quantity of the #K24 exhaust cloud imagery data available for validating dispersion models. However, it is difficult to extract the data for a single instant in time from summary plots that contain many minutes of ground cloud data. Therefore, in order to facilitate the comparison of these data to individual dispersion model runs, a subsequent report will provide a detailed review of the imagery. This subsequent detailed analyses will provide the data in a format that will allow direct comparison to model runs for specific times, altitudes, and distances from the release site.

The imagery-derived #K24 exhaust cloud imagery data are also available as comma-separated-variable files providing time and position for various ground cloud features. The raw visible imagery data are archived on VCR tapes. The raw infrared imagery are archived on DAT. The selected visible and infrared images analyzed for this report are also archived on magneto-optical disks as digital image files.

2.2 Introduction

This section summarizes the results of quantitative visible and infrared imagery of the exhaust cloud from the Titan IVB #K24 launch from SLC-40 at CCAS on 23 February 1997 at 1520 EST (2020 GMT). Personnel from the Aerospace Corporation's Environmental Monitoring and Technology Department (EMTD) supported this launch with the deployment of four complete

platforms of the Titan IVB-dedicated Visible and Infrared Imaging System (VIRIS). For the #K24 afternoon launch, the imagery from four sites permitted the post-launch quantitative analysis of the ground cloud's movement and growth as a function of time. The imagery sites chosen for the #K24 launch were (1) along Beach Road across from UCS-4 (north-northeast of SLC-40), (2) at the third bollard along the northeast edge of the pond at Press Site (northwest of SLC-40), (3) at UCS-2 (southwest of SLC-40), and (4) on top of tower 60691 along Hangar Road near Skid Strip (south of SLC-40). Each site recorded both visible and infrared imagery. The infrared imagery provided better contrast for the ground cloud against the abundant atmospheric clouds and haze. Therefore, we used the infrared imagery to track the ground cloud.

Quantitative analysis of the infrared imagery for the first 6 min after launch documented the cloud's rise time, stabilization height, bearing, and speed without recourse to other data. The "ground cloud" is defined as the lower and more concentrated portion of the rocket's exhaust cloud that can diffuse to the ground. The "launch column" or contrail is defined as the trail of the rapidly moving rocket that extends above the more spherical "ground cloud."

The T-0.53h rawinsonde pre-launch meteorology data are documented in Appendix B and referenced in this section. Those rawinsonde wind data were used to run the "normal launch" REEDM predictions. The complete output for the T-0.53h REEDM predictions is documented in Appendix A and referenced in this section.

2.3 Field Deployment

2.3.1 Planning

The Aerospace Corporation's participants are listed in various teams below (members of the imaging teams for #K24 are indicated with asterisks):

Technology Operations
- Space and Environment Technology Center
  - Environmental Monitoring and Technology Department
    - R. N. Abernathy* and G. N. Harper* (Tower 60691)
    - J. Y. Webb* and J. T. Knudtson* (East of UCS-04)
    - P. Kasper* (UCS-02)
    - K. L. Foster* and J. T. Valero* (Pond at Press Site)

Space Launch Operations
- Systems Engineering Directorate
  - Environmental Systems
    - N. F. Dowling* (UCS-02 Site), Systems Director
    - H. L. Lundblad
- Eastern Range
  - Systems Engineering Directorate
    - D. R. Schulthess

2.3.2 Equipment

The equipment at each site included all the hardware and software necessary to record and document the launch, to communicate between sites, and to supply backup power in case of an outage at the fixed power distribution points. The VIRIS consists of an array of three full and one backup (excluding the IR imager) cloud tracking systems and was designed and fabricated at the request of Space Launch Operations, Systems Engineering Directorate, at The Aerospace Corporation. Each full tracking system consists of coaligned visible and infrared (IR = 8–12 μm) imagers, mounted on an azimuth- and elevation-encoding tripod, with an associated data acquisition and display console. The combination of visible and IR imagers permits cloud tracking in both daylight and darkness. The unique capabilities built into the VCR hardware include digital insertion of imager azimuth (AZ), elevation (EL), time, and GPS location. The system electronics is integrated in a single package, which has been ruggedized for field use. Pre-wiring of this package makes deployment of these imager systems straightforward, usually requiring less than 45 min for instrumentation at a site to become fully operational.

For the Titan IVB #K24 mission, the operators at each site set the FOV of the visible imager using the adjustable 10- to 110-mm electronic zoom lens (see Table 1). They also selected the best lens for the infrared imager. All operators rotated the tripod head to keep the ground cloud within the FOV as it moved from the launch pad.

All four imaging systems deployed for the Titan IVB #K24 mission were capable of total autonomy. Each VIRIS has an on-board differential-ready GPS receiver that can be used to document each imager's position with moderate spatial resolution. Typically, 35 m is the precision in the horizontal plane and 100 m is the precision in the vertical plane. This was the case for the Tower 60691 site. For two imagery sites (UCS-2 and Press), we obtained more accurate GPS data (2-m resolution). Due to a hardware failure at UCS-4 site, we had to interpolate its position (35-m resolution) using a map of Kennedy Space Center and Cape Canaveral Air Station. Gasoline powered AC generators (Honda Ex1000) are insurance against loss or absence of facility power. The Stirling cooler option for the AGEMA 900 series IR imager was chosen so that liquid nitrogen would not be required at the sites. Each unit is transportable in a standard utility wagon (e.g., Ford Explorer).

The Az/El angle encoder for all imager systems was calibrated using reference objects (e.g., SLC-40) within the field of view of the imager. When reference objects are not part of the geodetic survey database, the GPS location uncertainty is the dominant term in the positional accuracy. Imager pixelation and operator error in edge detection contribute as well to the error in defining

Table 1. Field of View (FOV) for Imagery Sites during #K24 Mission

Imagery Site	Imager Type (Visible or IR)	FOV(horizontal) (°)	FOV(vertical) (°)
(1) East of UCS-04	AGEMA Infrared	20.35	10.17
(1) East of UCS-04	Hitachi CCD Visible	22.98	17.52
(2) Pond at Press Site	AGEMA Infrared	41.45	19.56
(3) UCS-02	AGEMA Infrared	40.53	21.00
(4) Tower 60691	AGEMA Infrared	41.40	20.92

the cloud boundary. The 0.07° step-size in the tripod angle encoders is a third source of error. The analysis accuracy is determined either by the availability of optimal references for Az/El calibration or by the step size for the tripod angle encoder. Typically the VIRIS system provides 0.1° accuracy in both elevation and azimuth.

2.4 Processing of Imagery Data

The processing of the imagery data requires several transformations that are performed upon return to The Aerospace Corporation:

1. Digitizing frames of the visible imagery.
2. Measuring the pixel locations of the reference sites within each image (i.e., FOV and angular calibration).
3. Measuring the pixel locations of cloud features in digitized images.
4. Converting pixel locations to azimuth and elevation readings.
5. Calculating cloud characteristics (i.e., position in Cartesian coordinates relative to the launch pad).

The processing requires the use of specialized hardware and software. Visible images of the cloud are digitized at precise times, beginning with time intervals of 15 s, then 30 s, then 1 min as the cloud evolves. The AGEMA 900 infrared imagers produce digital images every 15 s in the field. A set of digitized images is selected for specific times following the launch and from each of the available imagery sites. Time, AZ, and EL are tabulated for each set. A setup file is created for each of these sets, containing all relevant information necessary to compute the cloud geometry using the imagery. The Aerospace program **PLMTRACK** is run to digitize the x, y, and z coordinates of cloud features. The x and y coordinates are reported relative to the launch pad while the z coordinate is reported as height above MSL. We converted the height MSL to height above ground level (AGL) by subtracting the 7 m MSL for the height of SLC-40. This allows direct comparison to REEDM's output.

PLMTRACK is a software program developed and maintained in the Environmental Monitoring and Technology Department (EMTD) of The Aerospace Corporation by Brian P. Kasper. It is designed to analyze pairs of cloud images synchronized in time. When using the **PLMTRACK Line Method**, the operator selects the location of a particular cloud feature in the images from the two imager sites by moving a screen pointer to the desired feature in each image and clicking a mouse button. **PLMTRACK** then calculates the point of nearest approach to the two rays defined by the selected points. The three-dimensional location of this feature is then written to a data file.

Another implementation of **PLMTRACK** is illustrated in Figure 1. When using the **PLMTRACK Box Method**, the operator draws a rectangle about a cloud feature in the images from the two imager sites by moving a screen pointer to the extreme corners of the rectangles and clicking a mouse button. **PLMTRACK** then calculates the closest approach for various rays as illustrated in Figure 1 and described below. The top of the cloud is defined by rays determining T1 and T2 (i.e., T1 $\times$ T2); the bottom is determined by rays defining B1 and B2 (i.e., B1 $\times$ B2); and the middle is defined by the geometric mean of top and bottom (i.e., M1 $\times$ M2). To define

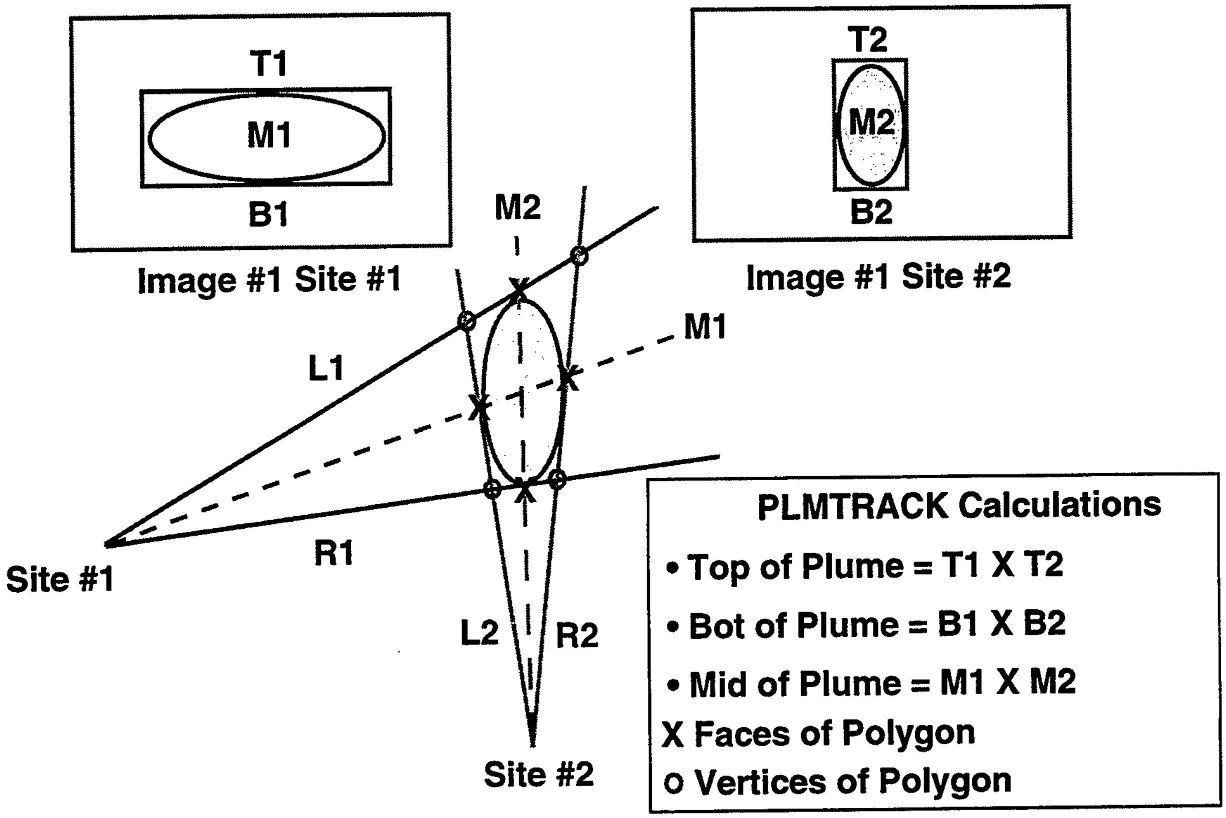


Figure 1. Implementation of the "box" method with two imagers.

the "faces" of the "box," the points of closest approach for ray M1 with L2 and R2 (the left and right tangents to the cloud from Imager 2) are defined (i.e., M1 $\times$ L2 and M1 $\times$ R2). A similar procedure is used to define the points of closest approach for M2 with L1 and R1, yielding M2 $\times$ R1 and M2 $\times$ L1. In addition to the centers of the faces of the "box," the intersects of the left and right rays document the four vertices for the XY polygon. Thus, eleven points are defined for the six-faced "box" surrounding the cloud (a point in the center of each of the six faces, four vertices for the XY polygon, plus a middle point for the "box"). These eleven sets of x, y, and z coordinates are written to a file.

When three imagers are viewing the cloud simultaneously, a six-sided polygon method (documented in Figure 2) has been employed as a way to document the maximum extent of the cloud (i.e., a ground-plane projection) for each set of images. With three imagers, there is a triply redundant determination of the top, middle, and bottom of the cloud by **PLMTRACK**. The horizontal extent of the cloud is determined by defining the rays from each imager that are tangential to the widest part of the cloud as seen from that site. Projection of these extreme rays for each imager on the x-y ground plane forms a polygon that bounds all material in the cloud at all altitudes, as shown in Figure 2. Thus, when an aircraft is flown against the ground cloud (i.e., #K15, #K16, #K22, and #K23 missions), one expects to see aircraft HCl sampling "hits" fall within this polygon, regardless of the sampling altitude. When the polygon area is combined with the mean cloud height (i.e., the difference between the top and the bottom of the cloud), one can obtain an upper bound for cloud volume. As illustrated in Figure 2 (a ground projection of the

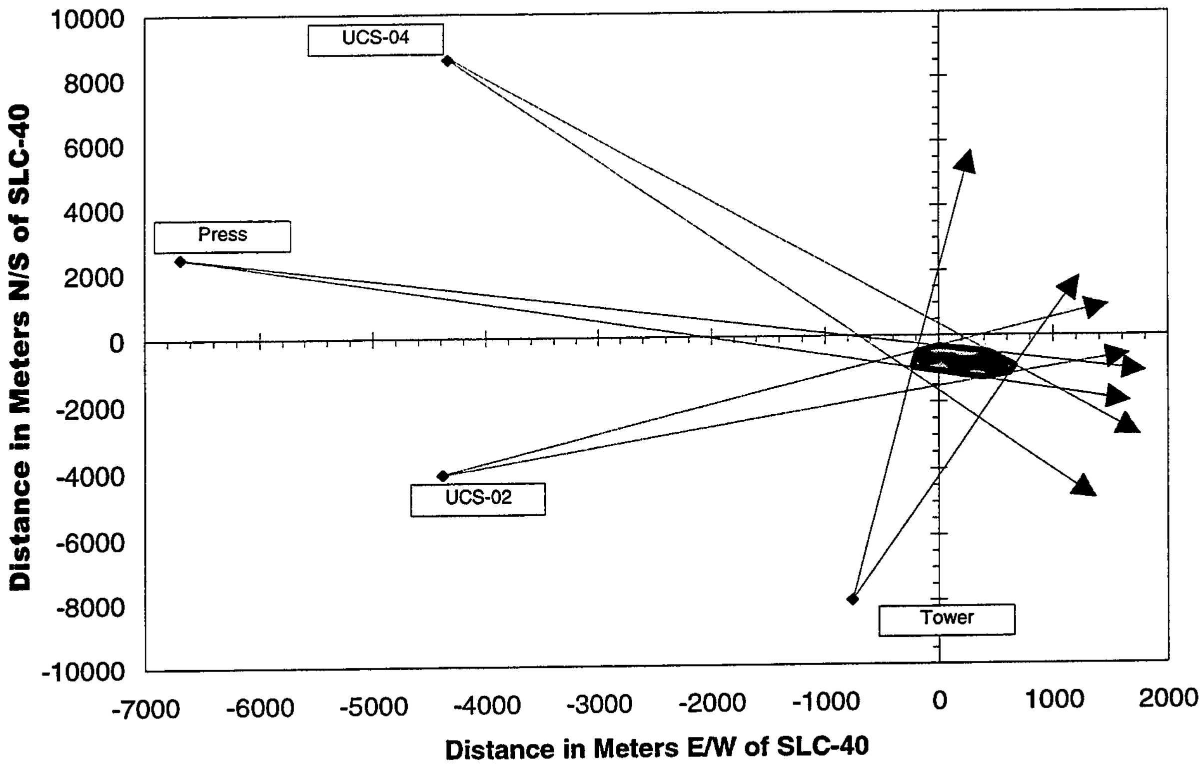


Figure 2. Implementation of the polygon method for two imagers. The imager positions and rays are actual #K24 data for T+01:30 (mm:ss) after launch. The cloud's shape was synthesized for heuristic purposes to illustrate that the shaded polygon can overestimate the clouds extent.

cloud's extent), the shaded area within the polygon typically overestimates the extent of the cloud (i.e., the smaller shape drawn within the polygon).

The utility of the polygon method has been documented in a previous report[1] for the #K23 mission. In that report, the polygons from imagery were correlated with aircraft's HCl measurements of cloud dimensions and average HCl concentrations for the Titan IVA #K23 launch cloud. After correcting for Geomet time response, the #K23 dataset established that HCl concentrations detectable by an aircraft-based Geomet total HCl detector were mostly contained by the six-sided polygon areas for the first 20 min after launch. The #K23 data established that the imagery-derived position of the visible cloud correlates with the measurable HCl concentrations. A similar treatment is possible with the #K24 imagery (without aircraft data) and allows a mapping of the growth and position of the cloud over time.

1. R. N. Abernathy, R. F. Heidner III, B. P. Kasper, and J. T. Knudtson, Visible and Infrared Imagery of the Launch of the Titan IV #K23 from Cape Canaveral Air Force Station on 14 May 1995, Aerospace Report No. TOR-96(1410)-1, The Aerospace Corporation, El Segundo, CA (15 September 1996).

2.5 Results and Discussion

2.5.1 Correlation of Ground Cloud Bearing with Wind Direction

Figure 3 presents the imagery-derived cloud track (i.e., as x-y position data) and the T-0.53h REEDM-predicted ground cloud trajectories (i.e., as arrows for the surface and stabilization height calculations). Figure 3 also documents the rawinsonde wind directions at the imagery-derived top, middle, and bottom of the stabilized ground cloud. Lastly, Figure 3 documents the locations of the rawinsonde release site and of the four imager sites (UCS-4, Press, UCS-2, and Tower) used by The Aerospace Corporation while imaging the #K24 cloud. All directions are reported in rawinsonde convention (defined fully in Subsection 2.5.4). Briefly, the arrows indicate the direction the cloud would move for a wind coming from the indicated angle (clockwise from north).

As illustrated in Figure 3, the quantitative imagery documented a shifting cloud bearing from 0° at lowest altitudes to 99° after stabilization. REEDM predicts a shift in cloud bearing during rise: 0° during rise shifting to 53° at stabilization. However, REEDM predicts the cloud's bearing as 352° to the maximum cloud concentration at the predicted stabilization height (i.e., 920 m AGL). This is substantially different from the predicted cloud bearing of 28° to the maximum cloud concentration at ground level. After stabilization, REEDM predicts a 300° cloud bearing at

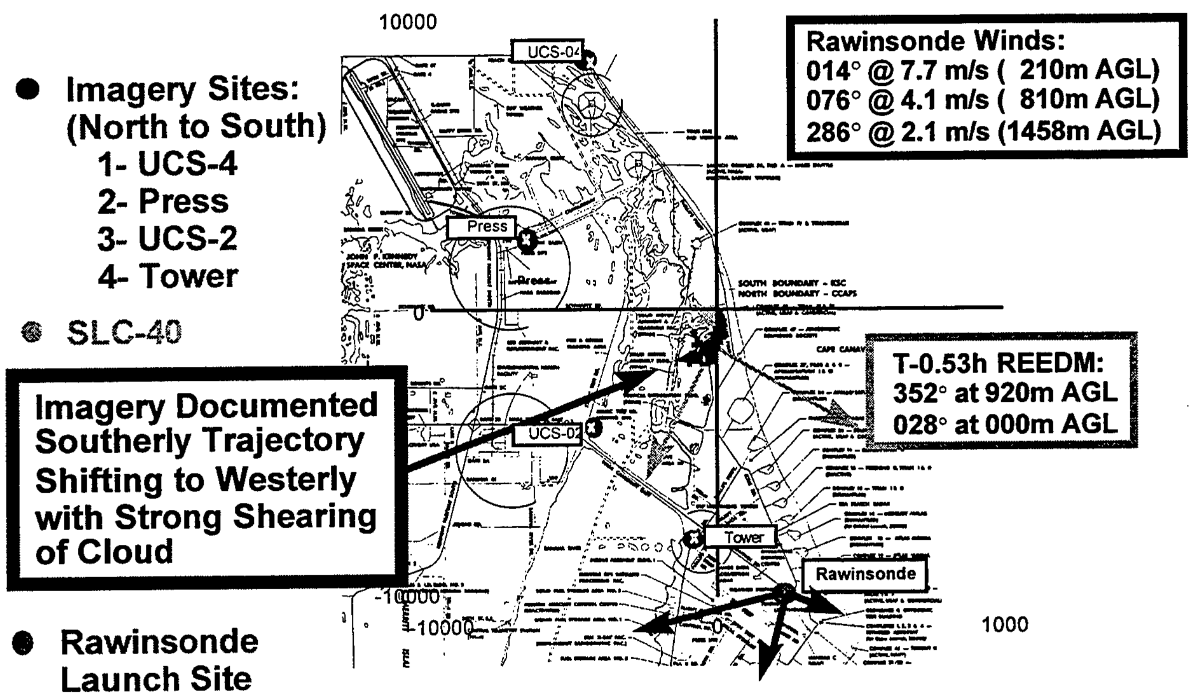


Figure 3. Map documenting the imagery sites, the rawinsonde release site, the #K24 ground cloud's bearing (derived from infrared imagery), the T-0.53h REEDM prediction for the ground cloud's bearings (surface and stabilization height), and the 1948 GMT (T-0.53h) rawinsonde wind directions at the measured cloud stabilization heights (bottom, middle and top).

920 m AGL (based upon the average wind in the second mixing layer). At ground level, the cloud's predicted bearing was 207° after stabilization. Figure 3 also presents the rawinsonde-derived wind directions (14°, 76°, and 286°) associated with the rawinsonde sounding heights (210, 810, and 1458 m AGL) nearest the bottom, middle, and top of the stabilized ground cloud, respectively. These wind directions are from the T-0.53h rawinsonde data and at the indicated sounding heights closest to the imagery-derived heights of 205, 803, and 1465 m AGL for the bottom, middle, and top of the ground cloud, respectively. Since SLC-40 is at 7 m MSL, you must add 7 m to height AGL to convert it to height MSL.

Figures 4 through 8 are selected visible and infrared images of the Titan IVB #K24 launch cloud from the indicated sites at the specified times after launch. Each figure contains two images to allow direct comparison. It is immediately obvious that the cloud is not spherically symmetrical in any of these images, and that the geometry of the cloud changes rapidly in the first few minutes after launch.

Figures 4 and 5 document imagery from Press and Tower sites, respectively, at an early time (2020:30 GMT = 30 s after launch). In each figure, the upper image is infrared, and the lower image is visible. It is apparent that the infrared provides better contrast for detecting the exhaust cloud against the cloudy and hazy background. In these images, the ground cloud is the broader low-altitude portion of the exhaust and is easily distinguishable from the thinner contrail.

Figure 6 documents infrared and visible imagery from the UCS-4 site at a slightly later time (2022 = 2 min after launch). It is apparent that the infrared continues to provide better edge detection for the exhaust cloud. There is less of a difference in widths of the ground cloud and contrail. Therefore, the analyst will use eddy structure features to track the rising ground cloud based upon review of all of the imagery.

Figure 7 documents infrared imagery for two times (30 s and 3 min after launch) from the UCS-2 site. These images document that the relative position and size of the ground and contrail clouds dramatically change over the first few minutes after launch. By three minutes after launch, the ground cloud fills over half of the FOV from this site. The ground cloud has risen to the same height as part of the contrail that now lies to the left (i.e., north) of the ground cloud.

Figure 8 documents simultaneous infrared imagery of the ground cloud from both Press and UCS-4 sites. These images reveal that the identification of the ground cloud is extremely difficult by 4.5 min after launch. Atmospheric moisture clouds surround the exhaust cloud. Some lie between the imagery sites and the cloud. In addition to these complications, it is difficult to distinguish the contrail from the ground cloud.

The imagery data were subjected to an iterative analysis to ensure that only cloud features contributing to the stabilized ground cloud (as documented by the entire 6 min of imagery) were included in the **PLMTRACK** "boxes."

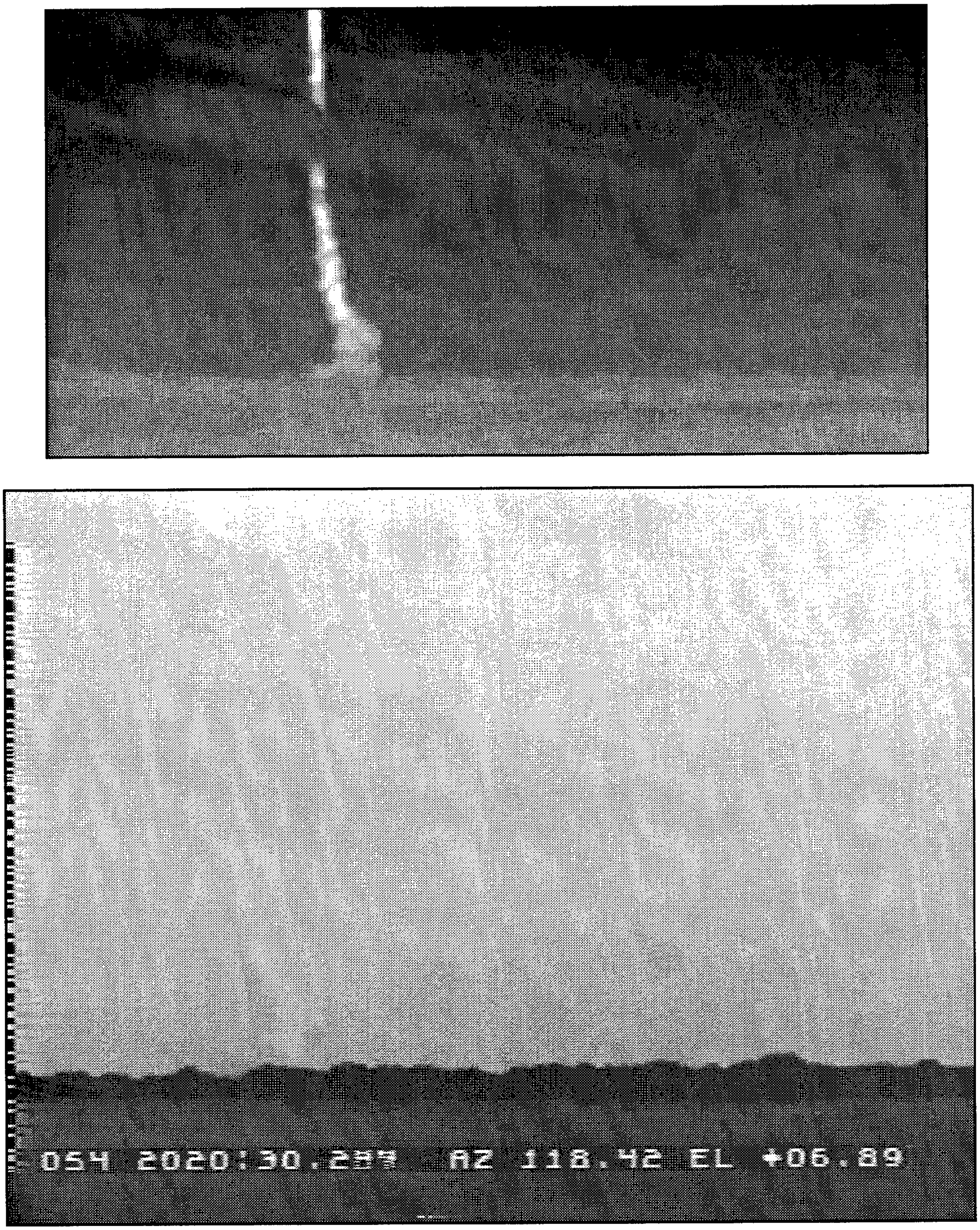


Figure 4. Imagery from Press site at 2020:30 GMT (30 s after launch): upper image is infrared; lower image is visible.

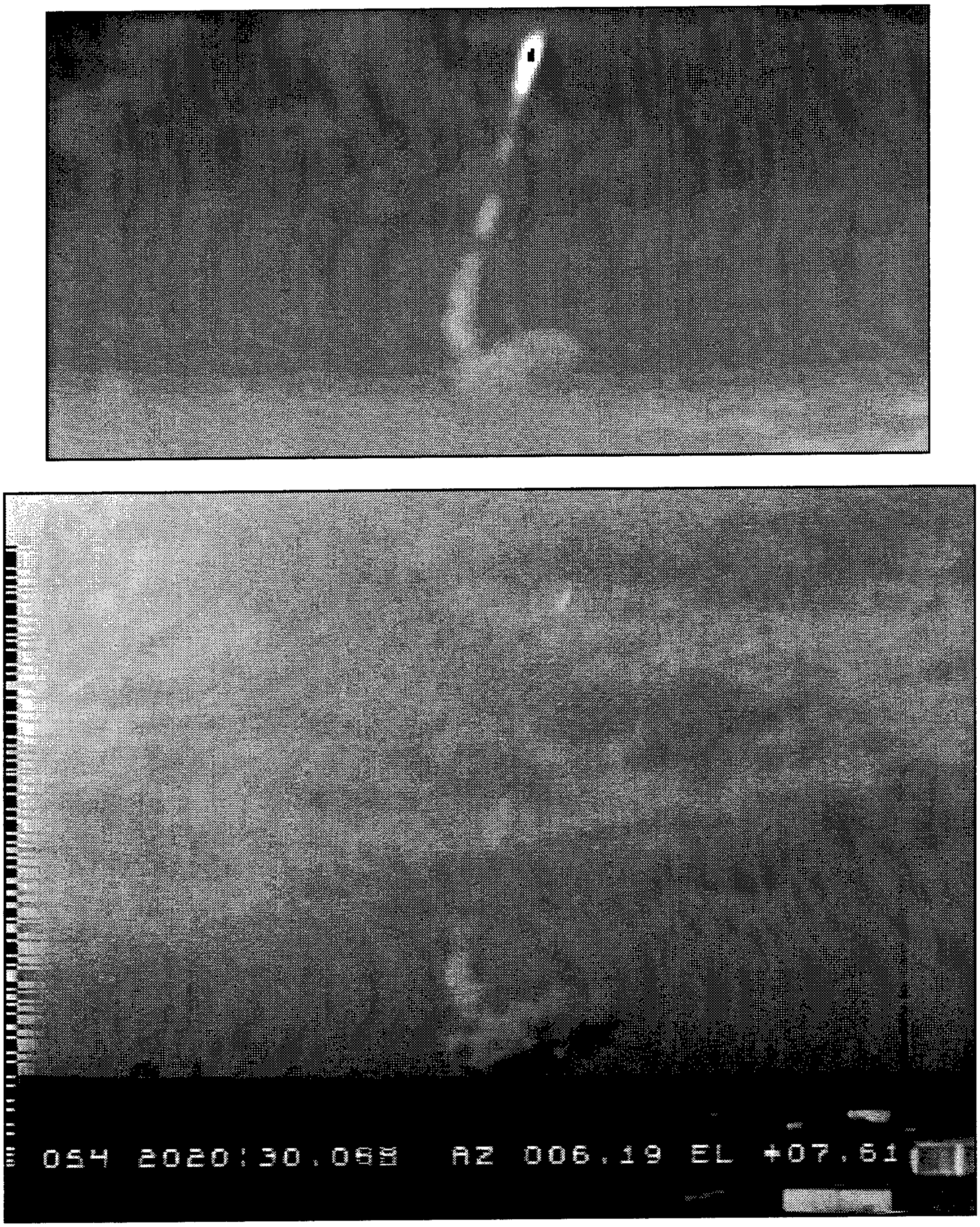


Figure 5. Imagery from Tower Site at 2020:30 GMT (30 s after launch): upper image is infrared; lower image is visible.

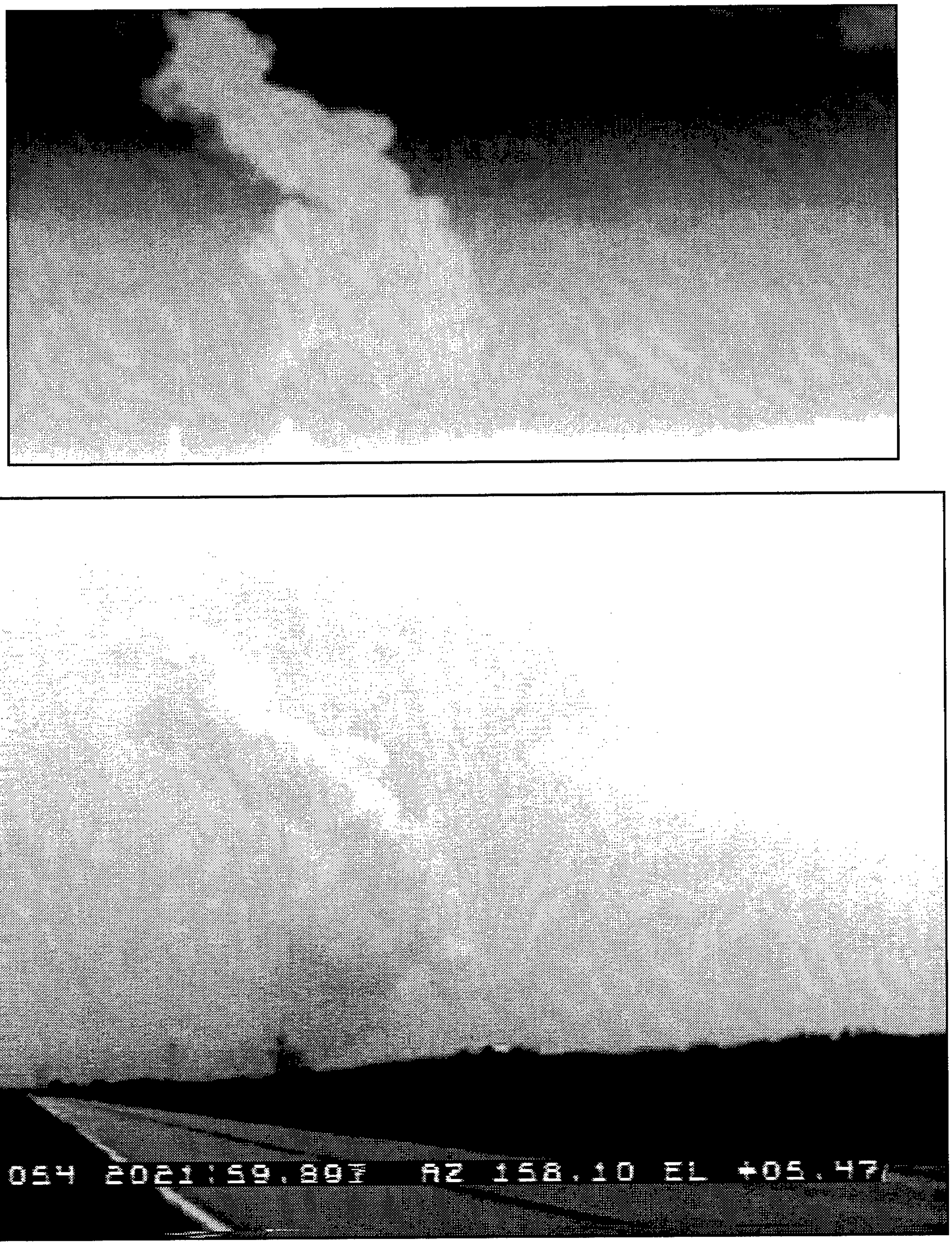


Figure 6. Imager from UCS-04 Site 2022:00 GMT (2 min after launch): upper image is infrared; lower image is visible.

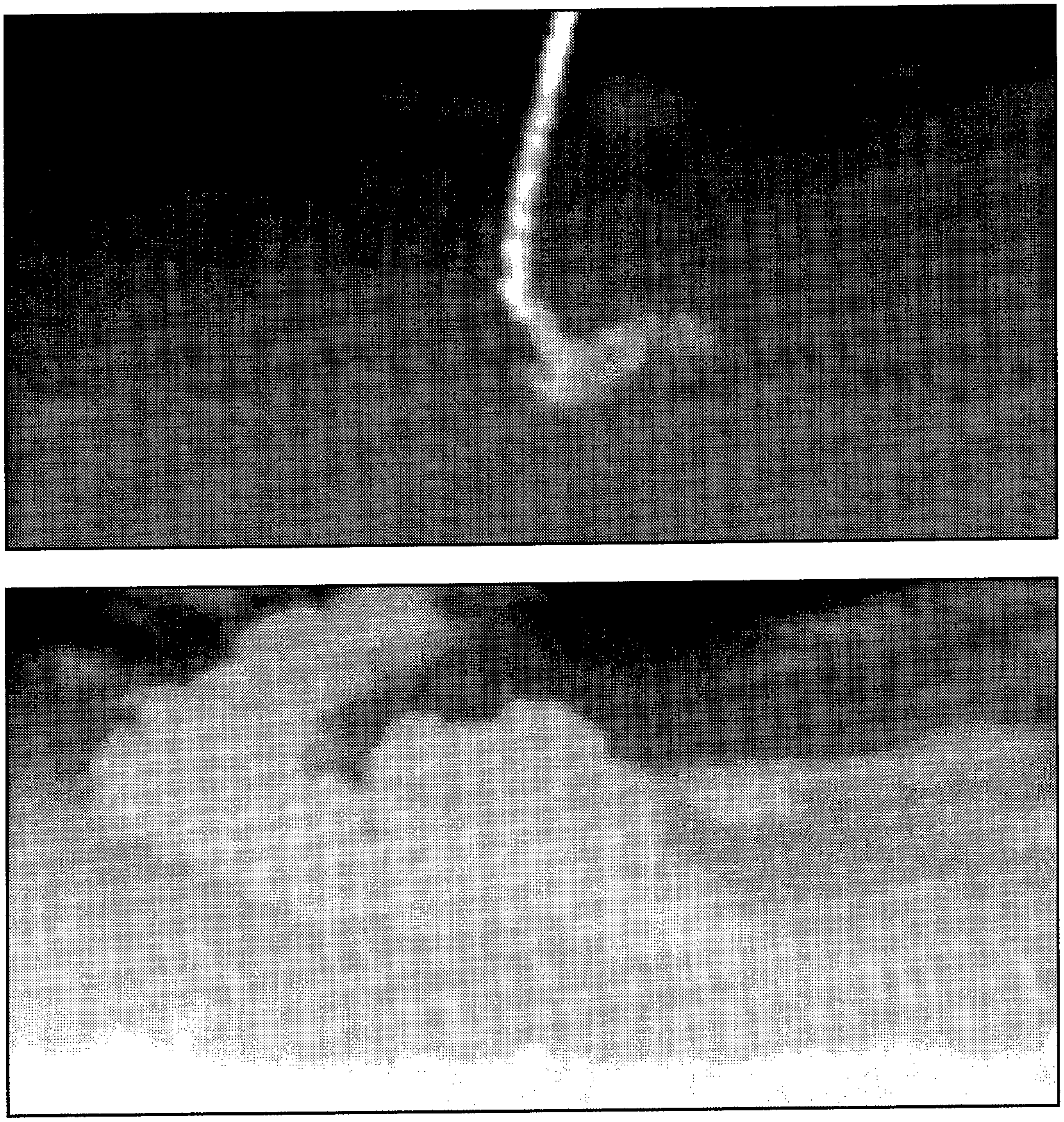
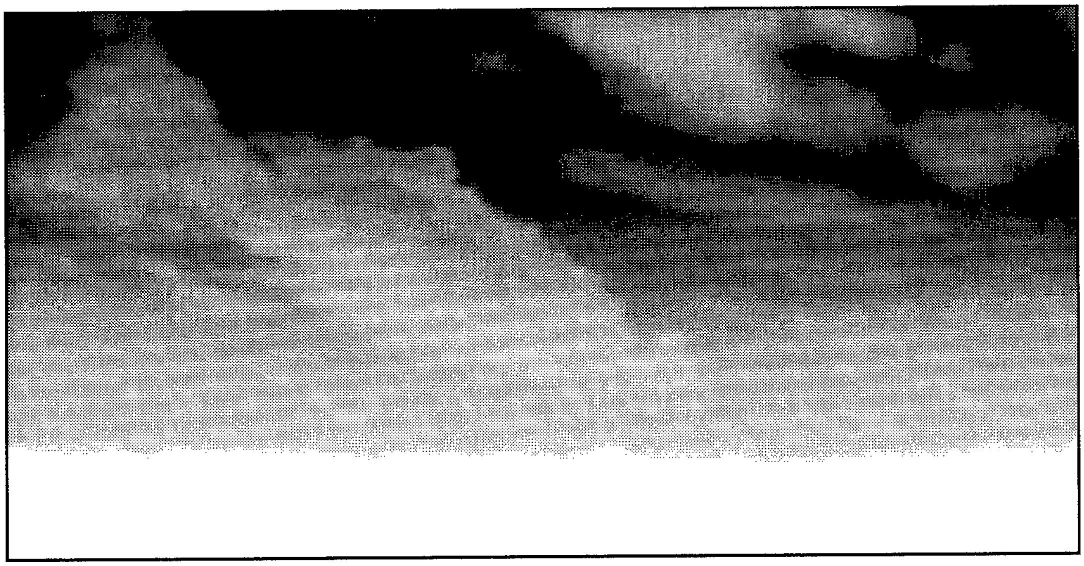


Figure 7. Infrared imagery from UCS-02 Site: upper image at 2020:30 (30 s after launch); lower image at 2023:00 (3 min after launch).



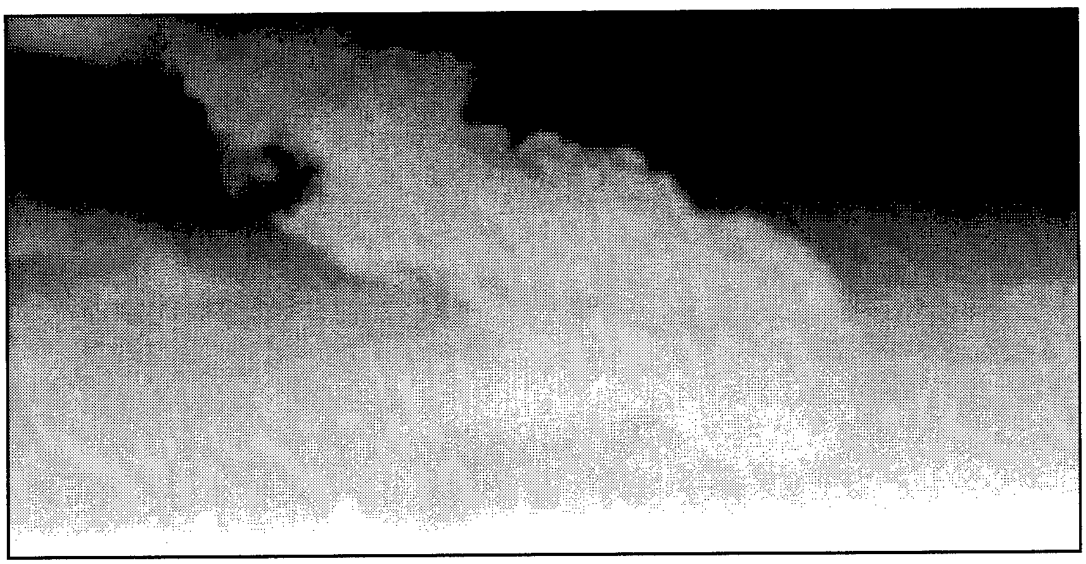


Figure 8. Images from two sites at 2024:30 GMT (4.5 min after launch): upper image from press site; lower image from UCS-04 Site.

2.5.2 Cloud Rise Times and Stabilization Heights

Figure 9 through 11present the imagery-derived, time-dependent altitude for the "bottom," the "middle," and the "top" of the ground cloud. These plots document the rise time and the stabilization height for each portion of the cloud. In these plots, all data are plotted as height in meters above SLC-40 (i.e., m Above Ground Level). The analyst used the **PLMTRACK Box Method** separately for each of seven pairs of imagery. In the upper plots, symbols identify the imagery-pairs used to track the cloud as defined in Table 2.

Table 2. Labels Used to Identify Imagery-Pairs used by PLMTRACK

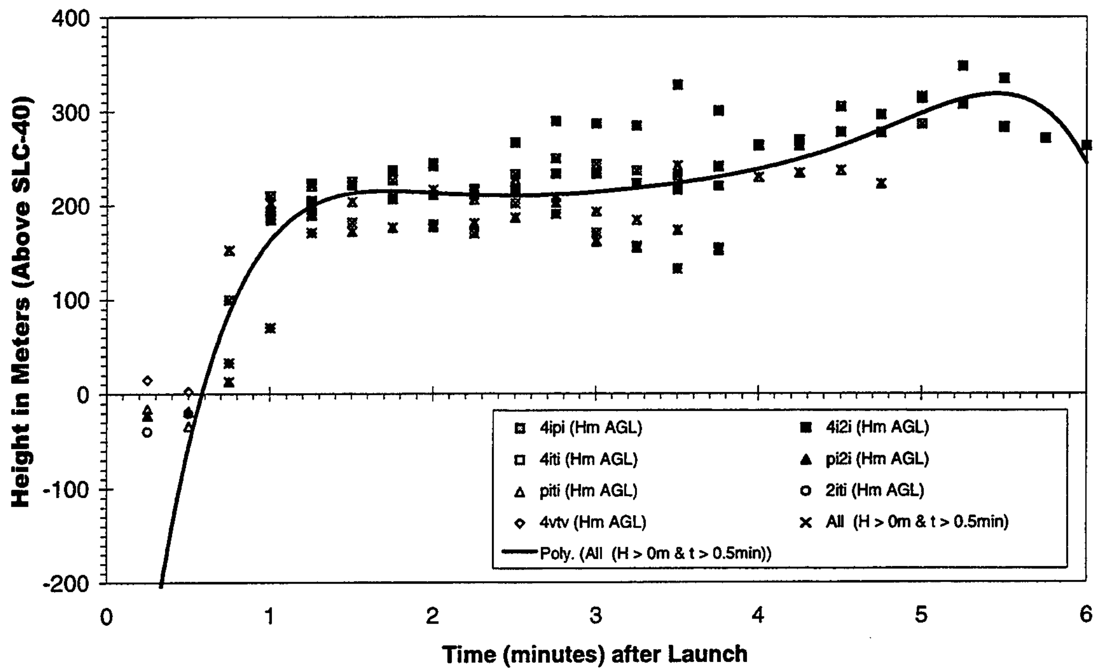
Label	Imagery Site 1	Imagery Site 2
4ipi	UCS-4; Infrared	Press; Infrared
4i2i	UCS-4; Infrared	UCS-2; Infrared
4iti	UCS-4; Infrared	Tower; Infrared
4vtv	UCS-4; Visible	Tower; Visible
pi2i	Press; Infrared	UCS-2; Infrared
piti	Press; Infrared	Tower; Infrared
2iti	UCS-2; Infrared	Tower; Infrared

For clarity, most plots include a polynomial fit to the combined data (i.e., all data independent of the imagery pair). It is apparent from the upper plots that some imagery pairs bias the data significantly. In the lower plots, it was important not to differentiate based upon the imagery pairs so that one obtains the average trend. The lower plots also include lines documenting the average stabilization height as well as the $\pm 3\sigma$ error bars for the stabilization height. It is apparent from review of these plots that the loss of imagery from UCS-2 at times later than 3.75 min significantly alters the average measured height. Therefore, we only used the data out to 3.75 min after launch (i.e., while still using imagery from all four sites) to calculate the average stabilization heights (i.e., the lower plots in Figures 9 through 11.

The variances (R^2) of the polynomial fits to the data indicate the quality of the fits. A polynomial fit was used in these figures as a convenient method to permit the representation of cloud overshoot and subsequent damped oscillation around the stabilization height. To be consistent with REEDM, stabilization time and height refer to the first maximum in these fits. REEDM predicts that the cloud goes through damped oscillatory motion with a period of $2\pi/S^{1/2}$, where S is the static stability parameter [Ref. 1, Eq. (7)].[2] Sensitivity of REEDM predictions to input parameters has been examined by Womack.[3] Careful imaging of launch ground clouds under a variety of meteorological conditions is a vital element in REEDM evaluation.

2 . J. R. Bjorklund, User's Manual for the REEDM Version 7 (Rocket Exhaust Effluent Diffusion Model) Computer Program, Vol. I, TR-90-157-01, AF Systems Command, Patrick AFB, FL (April 1990).

3 . J. M. Womack, Rocket Exhaust Effluent Diffusion Model Sensitivity Study, TOR-95(5448)-3, The Aerospace Corporation, El Segundo, CA (May 1995).



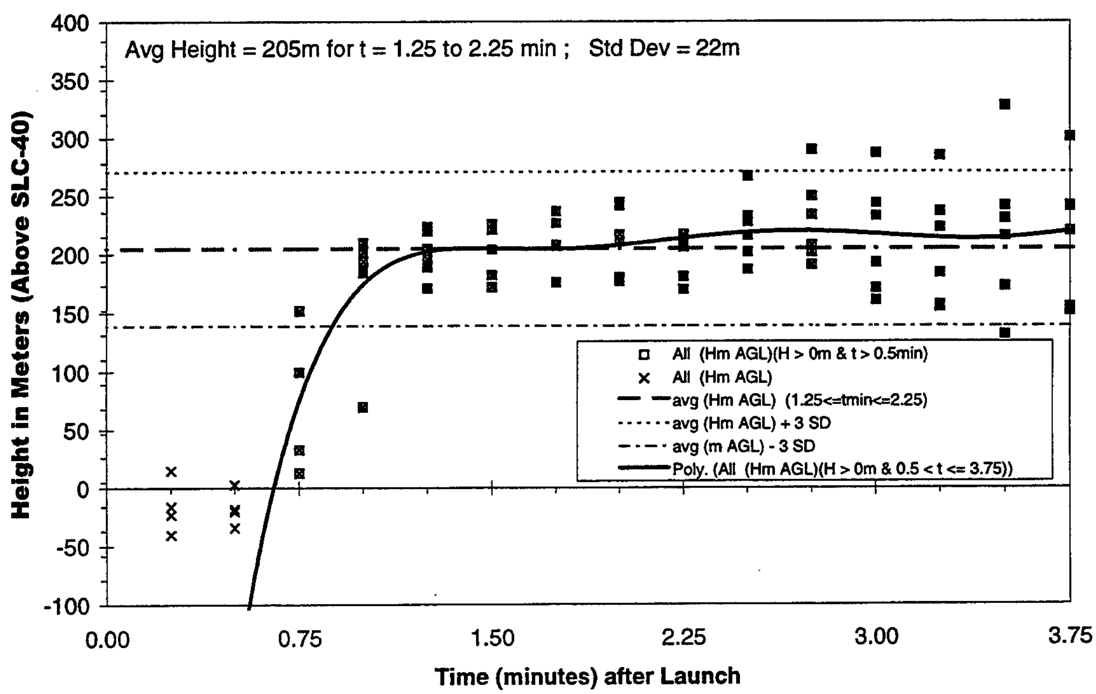
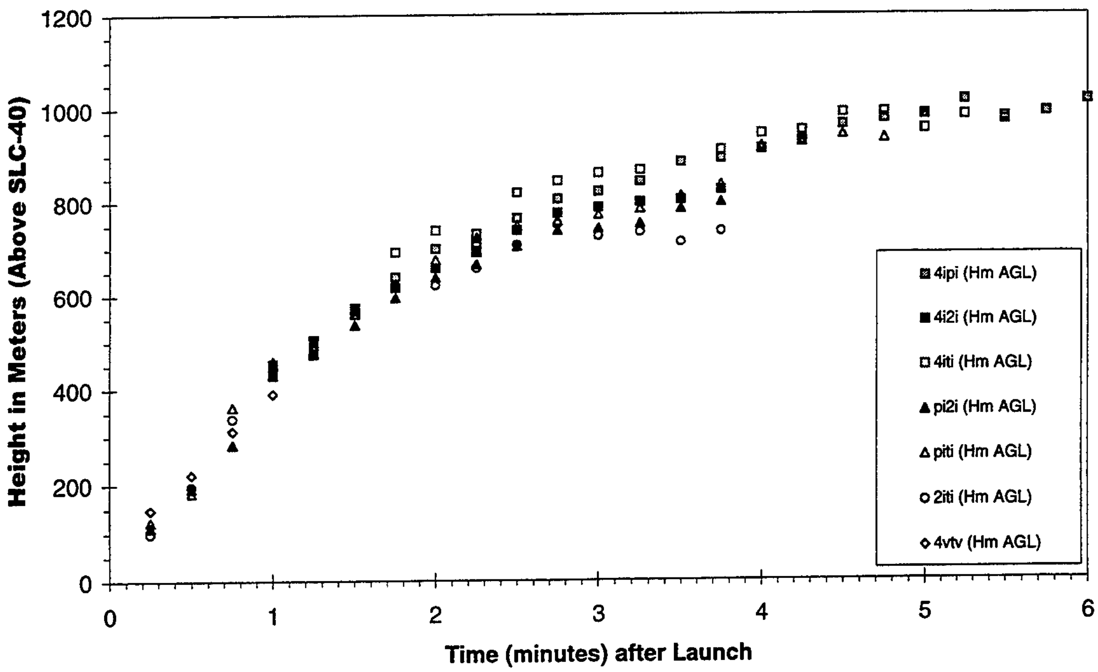


Figure 9. Cloud rise plots for the bottom of the #K24 ground cloud as determined using the PLMTRACK Box Method with pairs of imagery. The upper plots identify the imagery pairs used by PLMTRACK. The lower plots treat all data, independent of the imagery pairs, as one dataset. Lines document the polynomial fit, the average stabilization height, and the 3σ error bands for the stabilization height.



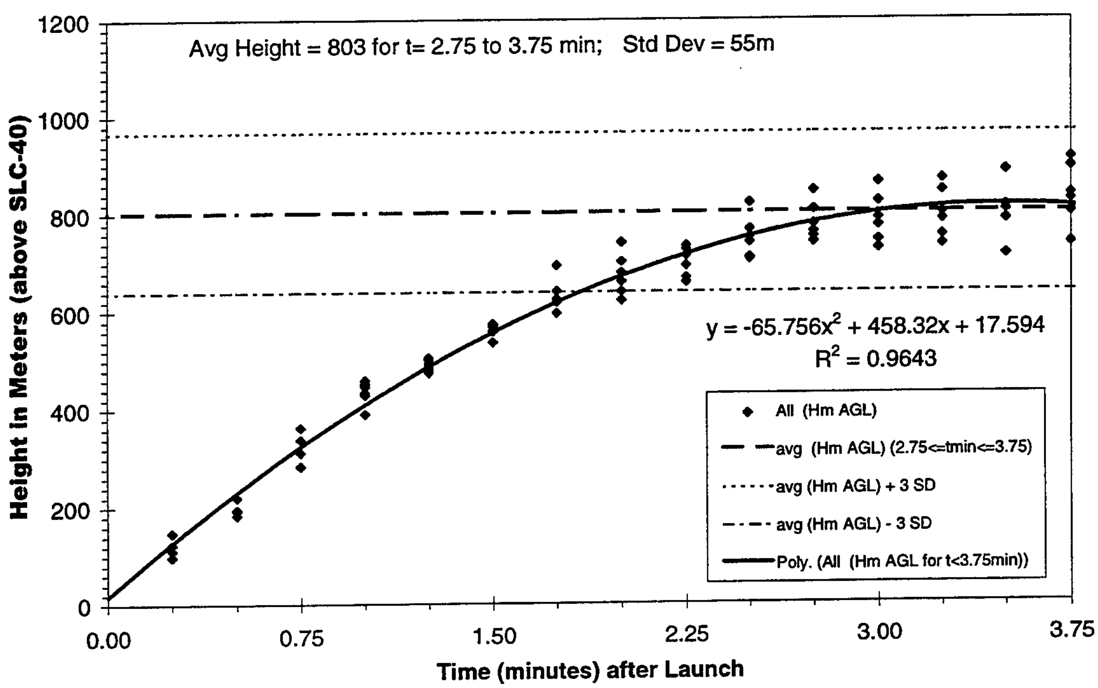
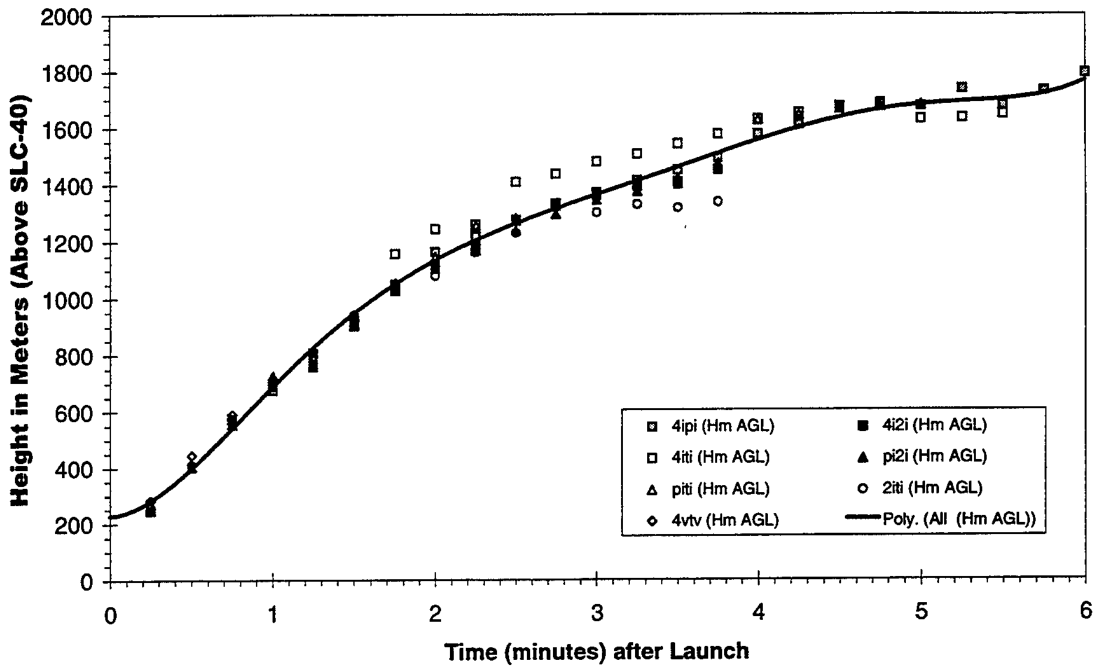


Figure 10. Cloud rise plots for the middle of the #K24 ground cloud as determined using the PLMTRACK Box Method with pairs of imagery. The upper plots identify the imagery pairs used by PLMTRACK. The lower plots treat all data, independent of the imagery pairs, as one dataset. Lines document the polynomial fit, the average stabilization height, and the 3σ error bands for the stabilization height. The variance (R^2) of 0.9643 indicates the high quality of the polynomial fit.



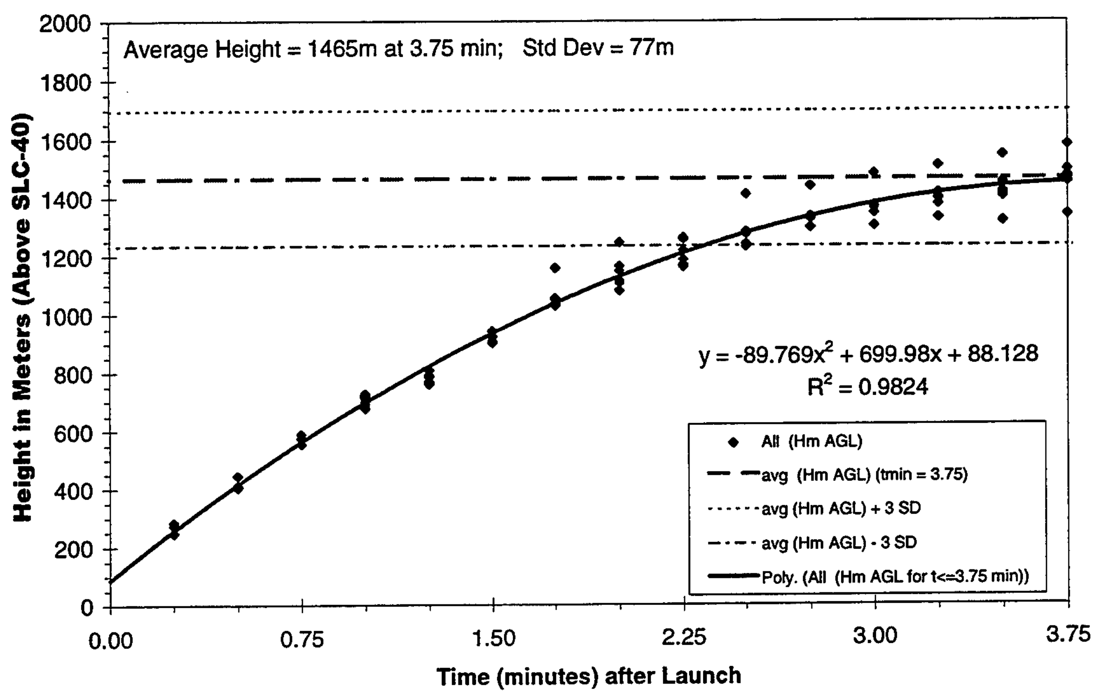


Figure 11. Cloud rise plots for the top of the #K24 ground cloud as determined using the PLMTRACK Box Method with pairs of imagery. The upper plots identify the imagery pairs used by PLMTRACK. The lower plots treat all data, independent of the imagery pairs, as one dataset. Lines document the polynomial fit, the average stabilization height, and the 3σ error bands for the stabilization height. The variance (R^2) of 0.9824 indicates the high quality of the polynomial fit.

2.5.3 Comparison of REEDM Prediction to Imagery Data—Stabilization Height

Figure 12 presents the imagery-derived heights for the ground cloud's top, middle, and bottom plotted as a function of time following the launch. It can be seen that the measured stabilization height of the middle of the ground cloud (803 m AGL ± 55 m) is 13% lower (approximately 2 standard deviations) than predicted (920 m AGL) by the T-0.53h REEDM modeling run (Appendix A). The time required to reach the stabilization height (i.e., between 2.75 and 3.75 min documented by quantitative imagery) is 4% to 29% faster than the 3.89 min predicted by the T-0.53h REEDM modeling run. This is excellent agreement between model and imagery for the first Titan IVB launch. REEDM has predicted stabilization heights 50% lower than observed for several Titan IVA launches at CCAS.

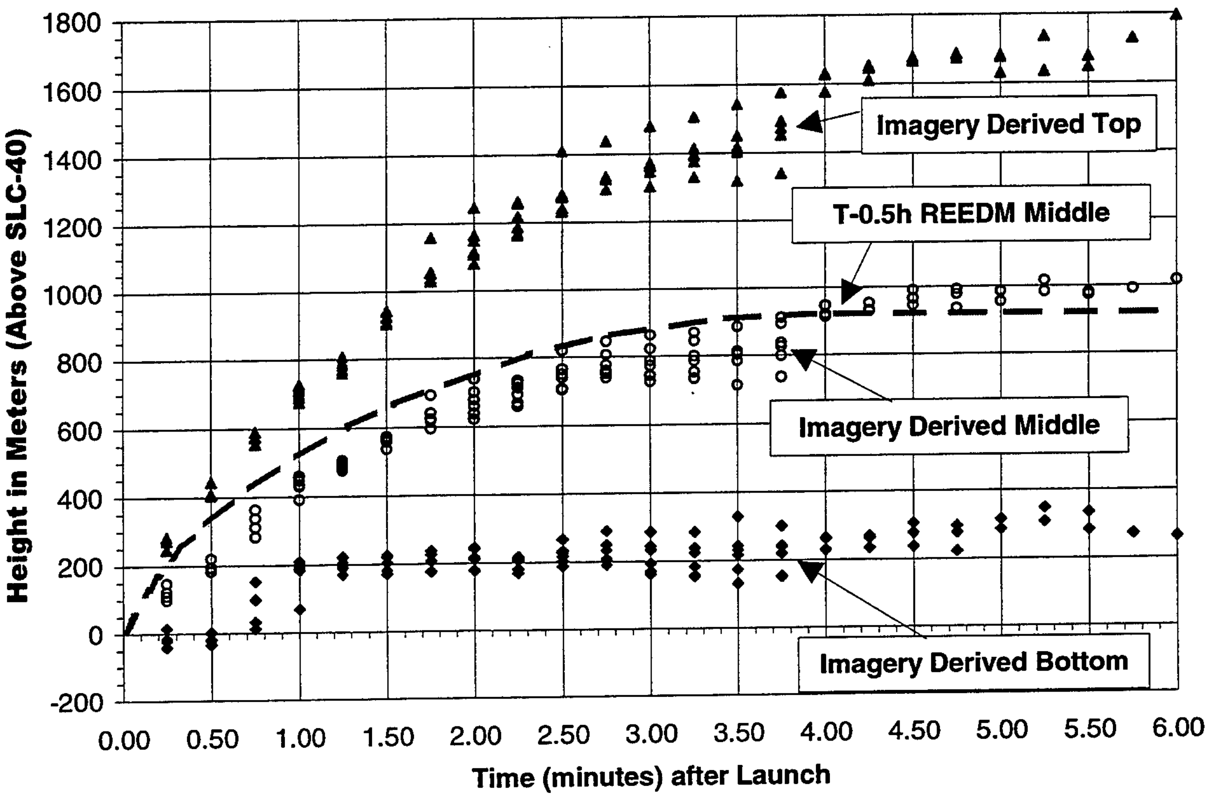


Figure 12. Imagery-derived stabilization heights compared to T-0.53h REEDM prediction. The plot includes the quantitative imagery data for the top, middle, and bottom of the ground cloud. For comparison, the plot also includes the T-0.53h REEDM modeling run prediction for the cloud's middle. The predicted stabilization height was 920 m AGL while the imagery-derived stabilization height was 803 ± 55 m AGL. This is excellent agreement for the Titan IVB.

2.5.4 Comparison of REEDM Prediction to Imagery Data—Bearing and Speed

Figures 13 and 14 document the plots typically used to derive the ground cloud's bearing and speed, respectively, from the quantitative imagery data. The **PLMTRACK Box Method** does not yield independent values for the top, middle, and bottom of the cloud. We have chosen to plot the data for the middle of the ground cloud.

Figure 13 plots the Cartesian coordinates for the middle of the ground cloud as distance north/south and distance east/west of SLC-40. This plot reveals that the cloud was ejected to the east by the exhaust duct. For about 0.5 min, the cloud moved south (0° bearing). Between 0.5 and 3 min after launch, the cloud had an average bearing of 27° (southwesterly movement). Between 3 and 6 min after launch, the stabilized cloud moved to the west (average bearing of 99°). The imagery documented a stretching of the ground cloud as it approached stabilization height. This is consistent with the wind shear documented by the rawinsonde sounding.

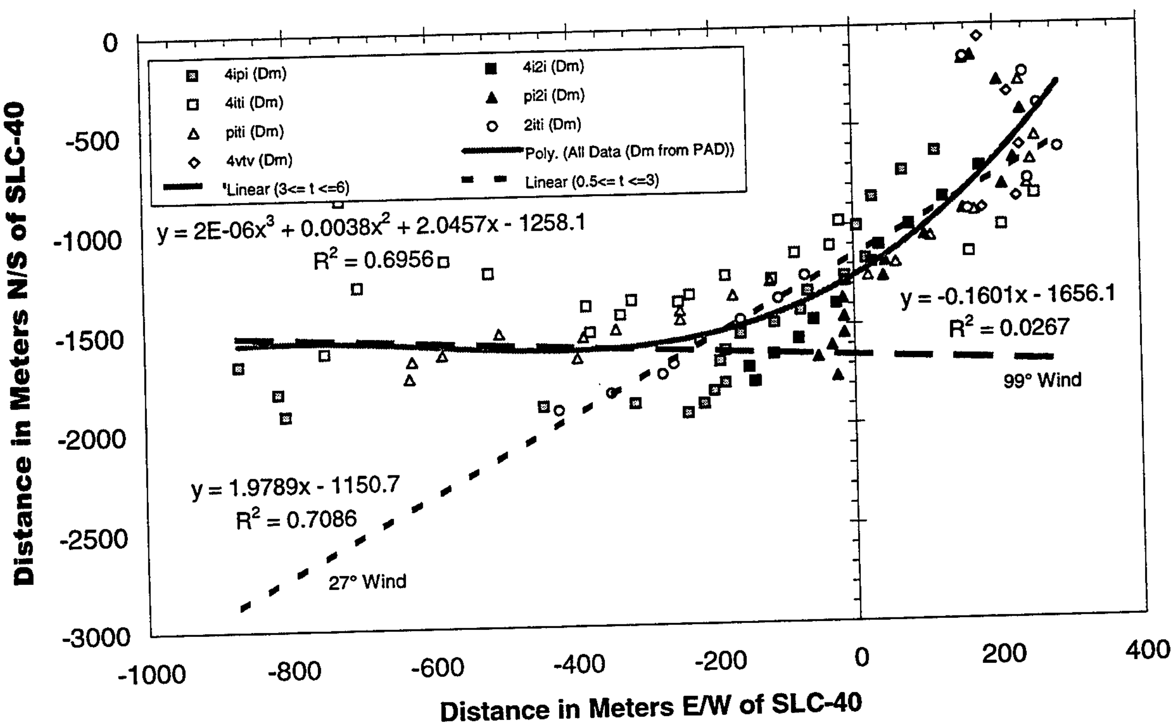


Figure 13. Cartesian plot documenting the imagery-derived ground cloud bearing for the #K24 mission. The symbols document the PLMTRACK imagery pairs used to derive the data. The lines are a least-squares linear fits to the combined data (i.e., independent of imagery pair) for the specified times. Therefore, the ground cloud moved along a bearing that varied from 0° to 99° during rise and after stabilization. This is qualitatively consistent with rawinsonde data.

In this report, the angles conform to the convention of rawinsonde wind vectors (the angle from which the wind originates that would push the cloud into its imaged position). Thus, the angles are related by

$$\vartheta = 180 + \Phi\,, \tag{2}$$

where ϑ is the equivalent rawinsonde wind angle and Φ is the measured polar angle of the cloud relative to SLC-40 and clockwise of true north. For example, when the cloud is due east of SLC-40, Φ is 90° and ϑ is 270°.

Figure 14 plots the ground distance from the middle of the exhaust cloud to SLC-40 against time after launch. As with the cloud track (i.e., Figure 13), the determination of cloud speed is complicated by the fact that it did not move directly away from SLC-40. Therefore, the least-squares line fits the combined data (i.e., independent of imagery pair) for times shorter than 1.5 min after launch. The slope of this least-squares linear fit to the combined data documents a 10 m/s speed away from SLC-40 for the rising ground cloud. The decrease in speed away from SLC-40 at later times is due to the shift in cloud direction.

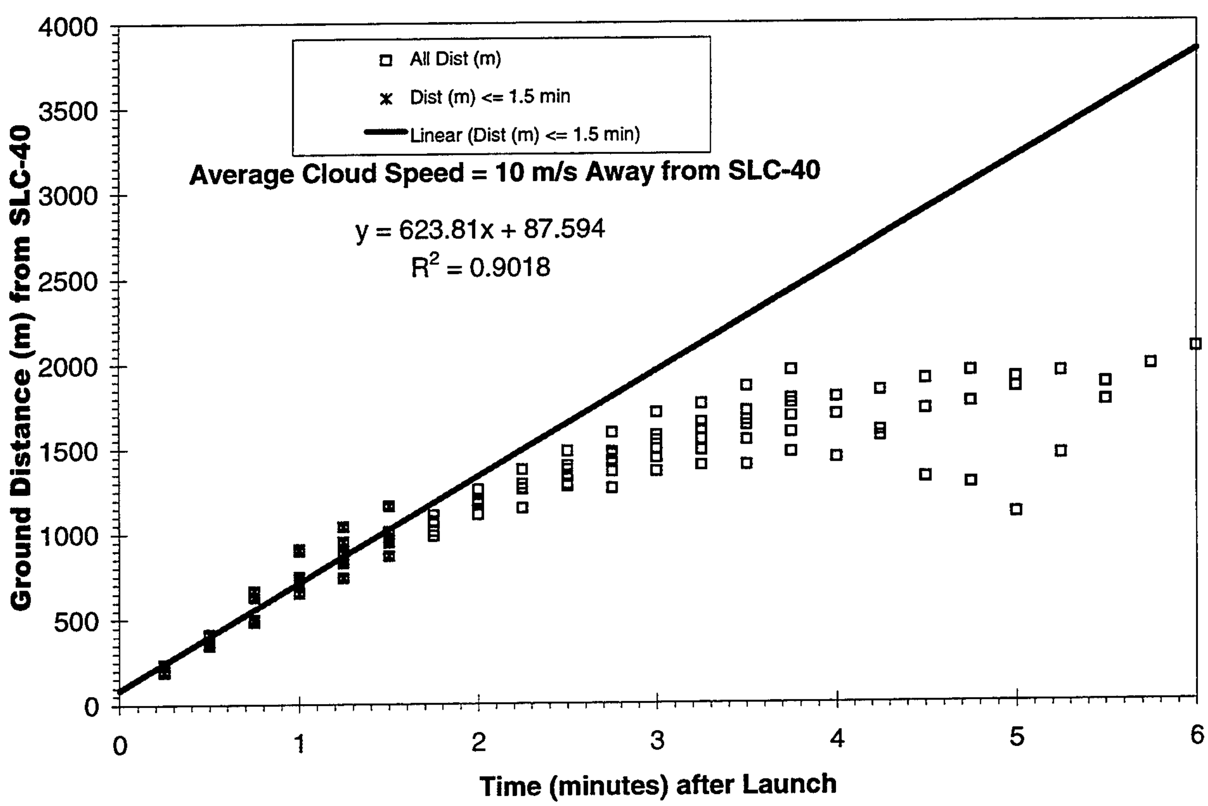


Figure 14. Time plot of the ground distance from SLC-40 for the #K24 exhaust cloud. The symbols document the PLMTRACK imagery pairs used to derive the data. The line is a linear fit to the combined data (i.e., independent of imagery pair) for times shorter than 1.5 min. Therefore, the ground cloud moved at 10 m/s away from SLC-40 during its rise.

Figure 15 documents the 1-min differential direction and speed for the ground cloud during the entire 6 min of imagery. These data are the result of calculations using data separated by 1-min intervals. This plot documents quantitatively that the cloud's bearing shifted from south to northwest while its speed dropped from over 11 m/s to as low as 4 m/s during its rise and stabilization. The average and standard deviations for the wind direction and wind speed at 3.5 min after launch are 5.2 ± 1 m/s and 31° ± 20°. The imagery data document that the cloud is stabilized by this time.

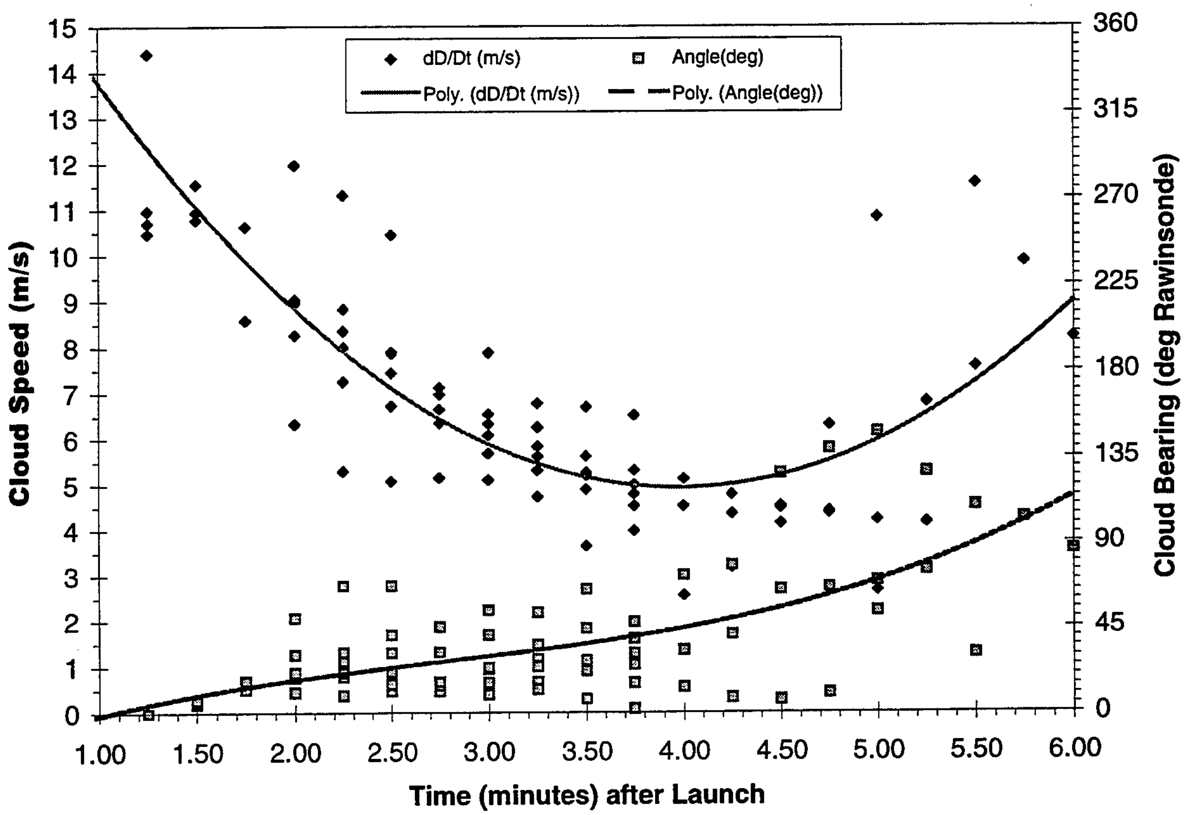


Figure 15. Time plot of imagery-derived average speed and average direction. These data are calculated from the change in position for the middle of the ground cloud using a 1-min differential. For example, the cloud was moving at 5.2 ± 1 m/s at 31° ± 20° at 3.5 min.

2.5.5 Comparison of REEDM Prediction to Imagery Data—Summary Table

Table 3 summarizes the imagery derived, the T-0.53h rawinsonde measured, and the T-0.53h REEDM-predicted data for the #K24 ground cloud. Several conclusions can be derived from review of the contents of this table and from the discussions in previous sections of this section:

(1) the imagery-derived stabilization height (803 m AGL) is 13% lower (more than 2 standard deviations) than the T-0.53h REEDM predicted stabilization height (920 m AGL);

(2) the imagery-derived stabilization time (2.75–3.75 min) is 4 to 29% faster than the T-0.53h REEDM predicted stabilization time (3.89 min);

(3) the imagery-derived bearing (shifting from 27° to 99°) is dramatically different from REEDM's predicted bearing (300°) at 920 m after stabilization;

(4) the imagery-derived cloud speed (5–9 m/s after stabilization) is faster than the wind speeds measured by rawinsonde at the imagery-derived height of the middle of the ground cloud; and

(5) the imagery-derived cloud speed (5–9 m/s after stabilization) is faster than the 3.5 m/s average wind for the second mixing layer (i.e., REEDM's predicted speed for the stabilized ground cloud).

Table 3. Summary of #K24 Ground Cloud Data Derived from Infrared Imagery, T-0.53h Rawinsonde Sounding Data, and T-0.53h REEDM Predictions

Attributes	Feature	Imagery (IR only)	Rawinsonde (T-0.53h)	REEDM 7.08 (T-0.53h)
Height (m)	Top	1465	1458	1596
above SLC-40	Middle	803	810	920
(SLC = 7 m MSL)	Bottom	205	210	417
Time (min)	Top	3.75	#N/A	#N/A
after launch	Middle	2.75–3.75	#N/A	#N/A
	Bottom	1.25–2.25	#N/A	#N/A
Bearing (°)	Top	#N/A	286°	#N/A
(rawinsonde)	Middle	27° to 99°	76°	300
	Bottom	#N/A	14°	#N/A
Speed (m/s)	Top	#N/A	2.1	#N/A
along trajectory	Middle	5 to 9	4.1	3.5
	Bottom	#N/A	7.7	#N/A

2.6 Summary and Conclusions

The Titan IVB #K24 mission was launched successfully from the Eastern Range (SLC-40) at 1520 EST (2020 GMT) on 23 February 1997. Personnel from The Aerospace Corporation deployed four VIRIS platforms (using both visible and infrared imagery) to monitor the event and to track the evolution of the solid rocket motor exhaust cloud. The four chosen sites (UCS-4, Press, UCS-2, and Tower Site) were located to the north-northwest, northwest, southwest, and south relative to SLC-40. The VIRIS systems imaged the ground cloud for 6 min after the launch. When combined with the AZ/EL readings and the IRIG-B time data, the **PLMTRACK Box Method** documented the rise, stabilization, growth, speed, and bearing of the ground cloud for the

first 6 min after the launch. The imagery documented that the middle of the ground cloud remained within the first mixing layer throughout the tracking period. This quantitative imagery data for the #K24 ground cloud will be extremely useful for tuning current and future dispersion models.

The definition of the #K24 exhaust cloud's geometric features is complicated by its three-dimensional shape (i.e., not spherical). However, the imagery successfully documented this complex shape as the cloud evolved (i.e., asymmetric ejection from the exhaust duct, rapid rise of the hot ground cloud, and shear between the top and bottom of the ground cloud). The analyst included only the portions of the exhaust cloud that became incorporated into the stabilized ground cloud as revealed by infrared imagery.

Analysis of the imagery data presented in this report has focused on determining parameters that are directly comparable to REEDM predictions. For the Titan IVB #K24 launch, T-0.53h REEDM predictions were substantially different from those measured by imagery. According to the quantitative infrared imagery from four imagery sites, the ground cloud took 2.75–3.75 min to stabilize (4 to 29% faster than predicted), stabilized at 803 m AGL [13% Lower (approximately 2 standard deviations) than predicted], moved in a southwesterly to westerly direction (dramatically different from the southeasterly predicted bearing), and moved at an average speed of 5–9 m/s (significantly faster than predicted). The speed, direction, and the stabilization height are all important parameters that drive the hazard zone predictions.

The Aerospace Corporation has imaged 12 Titan IVA launches as part of the Model Validation Program. All of the available Titan IVA imagery documents that REEDM consistently underestimates the stabilization height of the ground cloud. Such overly conservative REEDM predictions can result in unnecessary launch holds at a considerable cost to the Air Force. Compared to previous Titan IVA launches, REEDM did a much better job with this first Titan IVB launch. Additional Titan IV A and B exhaust cloud data are needed to validate and to tune current and future dispersion models for both ranges (Vandenberg AFB and CCAS) and for the various meteorological conditions associated with round-the-clock and year-round launch schedules.

Appendix A—T-0.53h REEDM Version 7.08 Runs for #K24 Ground Cloud

[The material in this appendix was contributed by R. N. Abernathy of the Environmental Monitoring and Technology Department of The Aerospace Corporation's Space and Environment Technology Center.]

1. Background

On 23 February 1996, the Titan IV #K24 mission was successfully launched from Space Launch Complex (SLC-40) at Cape Canaveral Air Station (CCAS) at 1520 EST (2020 GMT). As part of the Model Validation Program (MVP), the resulting exhaust cloud was imaged from three camera sites. The analysis of the quantitative imagery documented the rise time, stabilization height, and the trajectory of the ground cloud. Ten regular Titan IV launches have been imaged in a similar manner by The Aerospace Corporation as part of the MVP. This was the first Titan IV "B" launch. The Titan IV "B" uses the Solid Rocket Motor Upgrade (SRMU). Titan IV exhaust cloud data are needed to validate and tune current and future dispersion models. Exhaust cloud data are needed for various meteorological conditions for both ranges (Vandenberg AFB and CCAS).

This appendix summarizes the Rocket Exhaust Effluent Diffusion Model (REEDM) predictions for the rise and dispersion of the exhaust cloud from the Titan IV #K24 launch. REEDM version 7.08 defaults were used in these normal launch runs. REEDM used the rawinsonde data from T-0.53h prior to the launch. This appendix includes figures and tables that document the output of REEDM. The predictions are compared in tabular and graphical form to the imagery-derived cloud characteristics and to the rawinsonde wind data at the imagery-derived heights for the bottom, middle, and top of the stabilized launch cloud. In addition, the REEDM predictions for cloud trajectory are compared to the imagery-derived cloud trajectory (Section 2) and to the rawinsonde wind directions (Appendix B). It is apparent from review of these data that these data are useful for the validation of current and future dispersion models.

When comparing imagery-derived cloud vectors to rawinsonde wind directions, we reported all angles (cloud bearings and wind directions) in the convention of rawinsonde wind vectors. This is the angle from which the wind originates that would push the cloud into its imaged position. For example, when the cloud is due east of SLC-40, (i.e., the cloud is at 90° clockwise from north), we report the bearing to the cloud as 270° (i.e., the rawinsonde equivalent wind direction). This allows direct comparison of the imagery-derived cloud data to rawinsonde data. This is not the case for the detailed REEDM output. REEDM reports its cloud bearings as the direction the cloud is moving (i.e., 180° out of phase with the rawinsonde wind direction).

Figure 1 shows the imagery-derived ground cloud track, the T-0.53h rawinsonde-measured winds, and the T-0.53h REEDM-predicted ground cloud tracks.

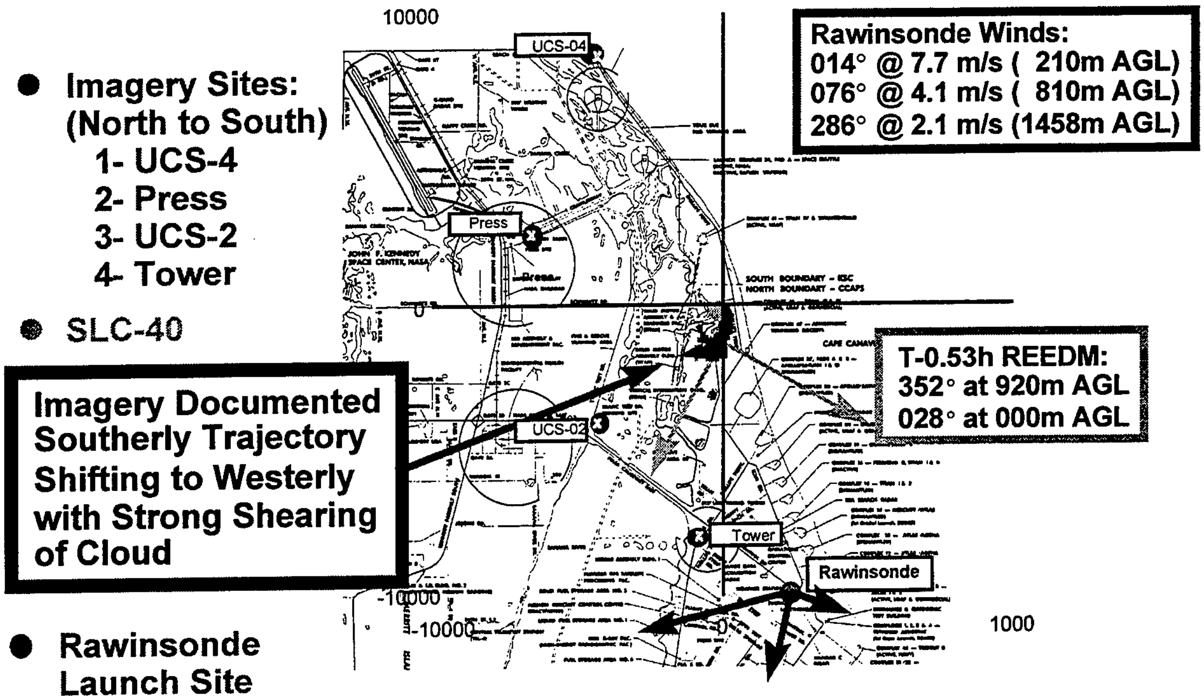


Figure 1. Map documenting the imagery-derived ground cloud track, the T-0.53h rawinsonde-measured winds, and the T-0.53h REEDM-predicted ground cloud tracks. The map also documents the positions of the three imagery sites and the rawinsonde release site.

2. T-0.5h REEDM Version 7.08 Normal Launch Predictions

REEDM version 7.08 was run for a normal launch using its operational defaults and the T-0.53h rawinsonde data (Appendix B). This section of the appendix begins with a figure that graphically compares the imagery-derived cloud trajectory, the rawinsonde-measured wind directions, and the REEDM-predicted cloud bearings (converted to rawinsonde equivalent wind directions). Next are the standard REEDM figures documenting the concentration isopleths and the centerline maximum HCl concentrations at the surface and at the predicted stabilization height. The last figure documents the REEDM meteorological summary plot. A summary table quantifies the similarities and differences between the imagery-derived cloud characteristics, the rawinsonde-measured winds, and the REEDM-predicted cloud characteristics. The table documents all angles as rawinsonde equivalent. The remainder of Appendix A is filled with the detailed tabular output for stabilization and surface runs.

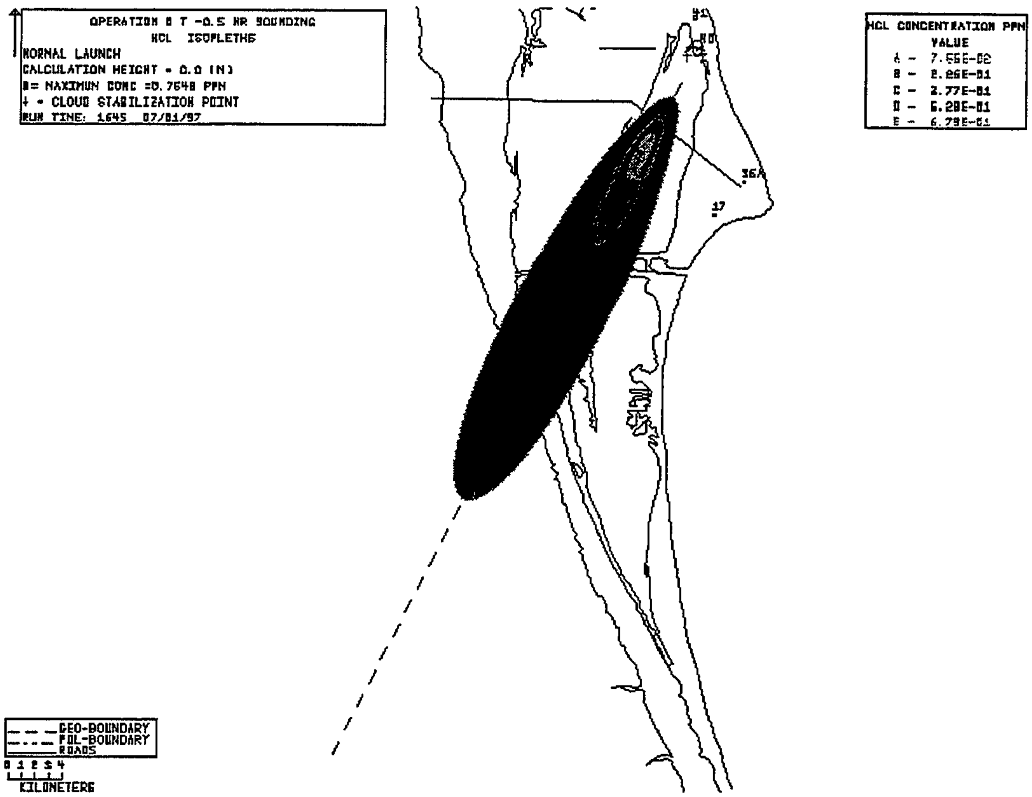


Figure 2. T-0.53h REEDM prediction for surface impact.

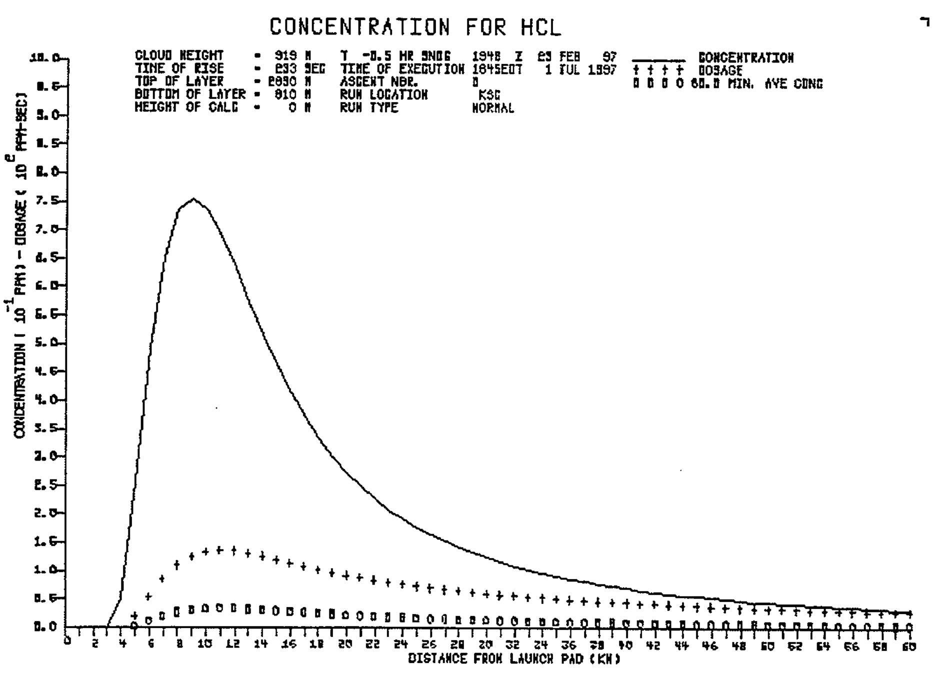


Figure 3. T-0.53h REEDM prediction of ground level center line HCl concentrations.

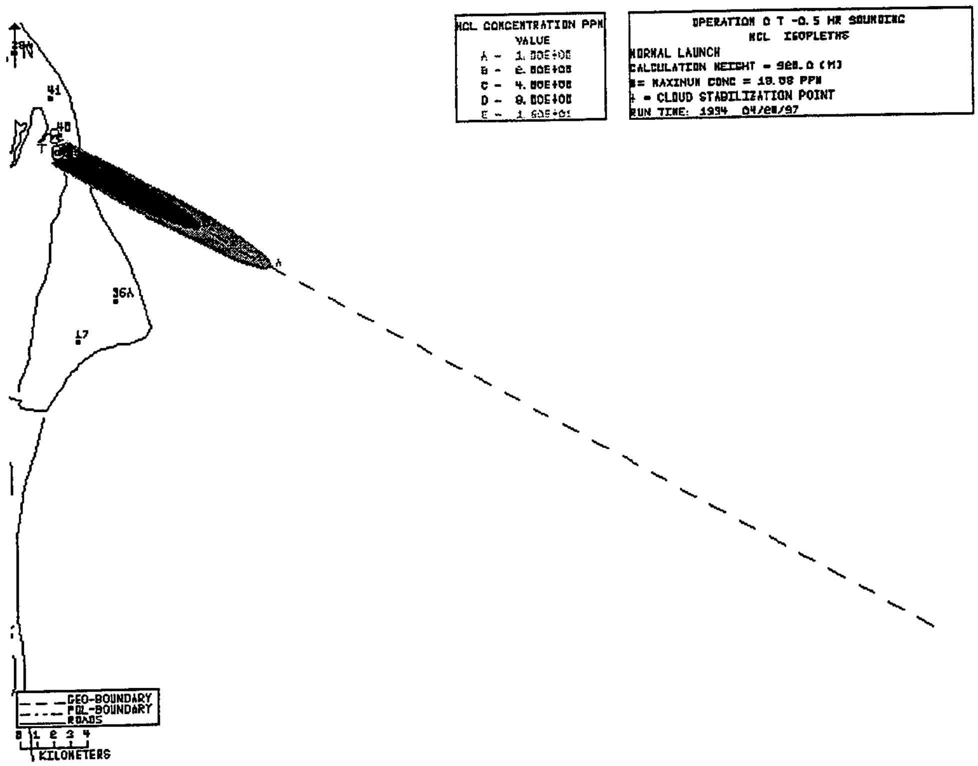


Figure 4. T-0.53 Hour REEDM prediction for stabilization height (m AGL = m MSL).

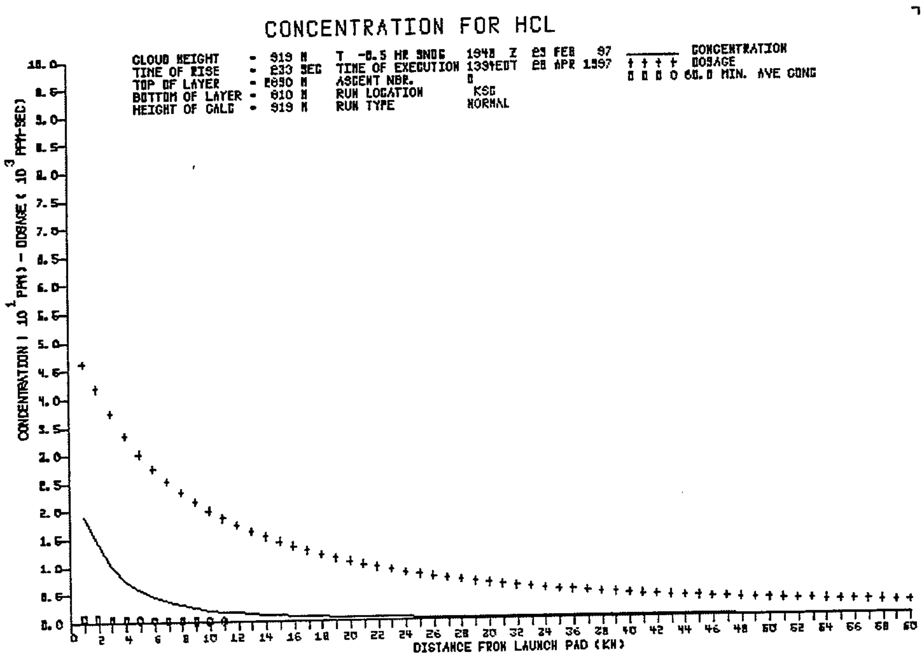


Figure 5. T-0.53 Hour REEDM prediction of the centerline hcl concentration at the stabilization height.

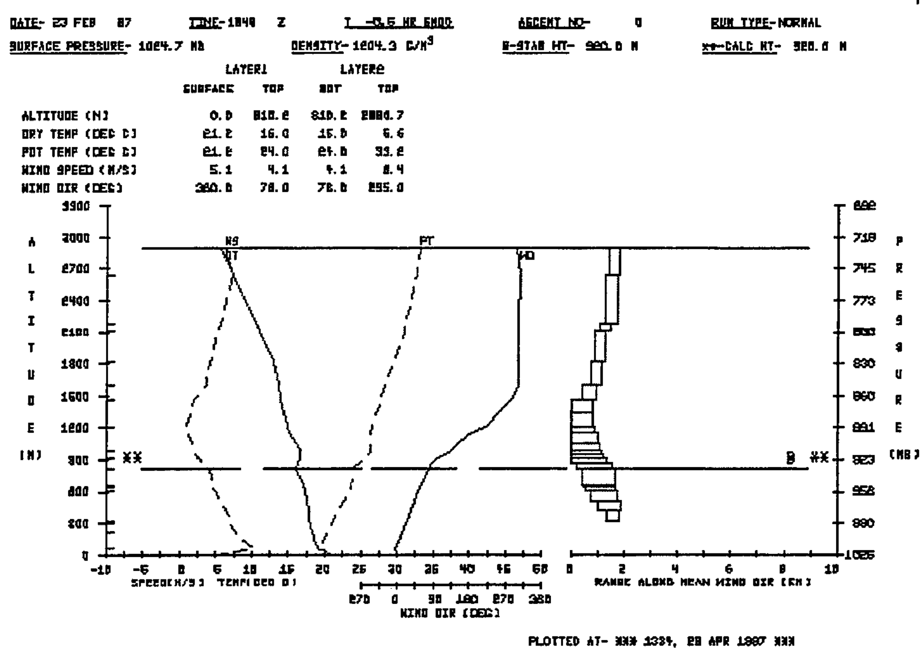


Figure 6. T-0.53 Hour REEDM Meteorological Plot from Stabilization Height Run.

Review of Table 1 reveals several interesting observations since it allows comparison of the observed #K24 cloud behavior with both the T-0.53h rawinsonde data and the T-0.53h REEDM predictions for the stabilized exhaust cloud. The imagery-derived stabilization height (803m AGL ± 55m standard deviation) was 13% lower than predicted (920m AGL). The difference is slightly larger than 2 standard deviations. The observed stabilization time (between 2.75 and 3.75 min) was 4% to 29% faster than predicted (3.89 min). This represents a relatively small difference. The imagery

Table 1. Summary of Imagery-Derived, T-0.53 hour Rawinsonde, and T-0.53 hour REEDM Data.

Attributes	Feature	Imagery (IR only)	Rawinsonde (T-0.53h)	REEDM 7.08 (T-0.53h)
Height (m)	Top	1465	1458	1596
above SLC-40	Middle	803	810	920
(SLC = 7 m MSL)	Bottom	205	210	324
Time (min)	Top	3.75	#N/A	#N/A
after launch	Middle	2.75–3.75	#N/A	#N/A
	Bottom	1.25–2.25	#N/A	#N/A
Bearing (°)	Top	#N/A	286°	#N/A
(rawinsonde)	Middle	27° to 99°	76°	300
	Bottom	#N/A	14°	#N/A
Speed (m/s)	Top	#N/A	2.1	#N/A
along trajectory	Middle	5 to 9	4.1	3.5
	Bottom	#N/A	7.7	#N/A

documented that the ground cloud's trajectory shifted from a bearing of 27° (i.e., between 0.5 and 3 min) to 99° (i.e., between 3 and 6 min). This is reasonable considering the strong wind shears apparent in the rawinsonde data (ranging from 14° to 286° over the altitudes occupied by the stabilized ground cloud) and the fact that the cloud was rising until 3.75 min after launch. REEDM predicts a shift in cloud direction during rise (i.e., 0° initially to 55° at the end of rise). This is qualitatively consistent with the imagery-derived cloud direction data. However, REEDM predicts a bearing of 352° to the maximum concentration at 920m AGL and a bearing of 300° for the stabilized cloud. The REEDM surface impact predictions are 28° to the maximum concentration at ground level and 27° for the cloud's ground impact trajectory at later times. The imagery-derived cloud speed ranges from 5 to 9 m/s for times longer than 3 min (i.e., after stabilization). For times longer than 3.75 min, there is a large uncertainty in the imagery data due to the loss of imagery from UCS-2 (i.e., the cloud overfilled the FOV).

3. Detailed REEDM Output for T-0.53h Runs

3.1 REEDM Stabilization Height Report for T-0.53 hour

The following 11 pages contain the detailed REEDM Version 7.08 report for the T-0.53h calculations relevant to the predicted stabilization height. The analyst accepted the default settings for all parameters including the heights for the first and second mixing layers. The first page of the REEDM output contains trouble shooting error codes that are beyond the scope of this report, and, therefore, that page is not included in this appendix. The REEDM report is presented in a different font so that the column headings align with the columns.

REEDM reports heights for the exhaust cloud as height above ground level (AGL). For the rawinsonde data, REEDM assumes 0 m AGL = 4.9 m MSL = the height of the rawinsonde release site. However, for the Titan IV exhaust cloud, one assumes 0 m AGL = 7 m MSL = the height of SLC-40.

```
1*****************************************************************************
              ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM        PAGE    2
                         VERSION 7.08 AT  KSC
                         1334 EDT 28 APR 1997
                   launch time:  1520 EST 23 FEB 1997
     RAWINSONDE ASCENT NUMBER        0, 1948     Z 23 FEB    97  T  -0.5 HR
*****************************************************************************
```

----- PROGRAM OPTIONS -----

```
MODEL                                                           CONCENTRATION
RUN TYPE                                                          OPERATIONAL
WIND-FIELD TERRAIN EFFECTS MODEL                                         NONE
LAUNCH VEHICLE                                                TITAN IVB SRMU
LAUNCH TYPE                                                            NORMAL
LAUNCH COMPLEX NUMBER                                                      40
TURBULENCE PARAMETERS ARE DETERMINED FROM                  CLIMATOLOGICAL DATA
SURFACE CHEMISTRY MODEL                                absorption coefficient
SPECIES        SURFACE FACTOR                              HCL            0.000
CLOUD SHAPE                                                        ELLIPTICAL
CALCULATION HEIGHT                                              STABILIZATION
PROPELLANT TEMPERATURE (DEG. C)                                         19.59
CONCENTRATION AVERAGING TIME (SEC.)                                   3600.00
mixing layer reflection coefficient (RNG- 0 TO 1,no reflection=0)      1.0000
DIFFUSION COEFFICIENTS                                     LATERAL     1.0000
                                                           VERTICAL    1.0000
VEHICLE AIR ENTRAINMENT PARAMETER                          GAMMAE      0.6400
DOWNWIND EXPANSION DISTANCE (METERS)                       LATERAL     100.00
                                                           VERTICAL    100.00
```

----- DATA FILES -----

INPUT FILES

```
RAWINSONDE FILE                                                  k24_1948.raw
DATA BASE FILE                                                   rdmbase.ksc
```

OUTPUT FILES

```
PRINT FILE                                                       k2481948.stb
PLOT FILE                                                        k2481948.stp
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1***

ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM PAGE 3
VERSION 7.08 AT KSC
1334 EDT 28 APR 1997
launch time: 1520 EST 23 FEB 1997
RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR

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----- METEOROLOGICAL RAWINSONDE DATA -----

RAWINSONDE MSS/MSS
TIME- 1948 Z DATE- 23 FEB 97
ASCENT NUMBER 0

----- T -0.5 HR SOUNDING -----

MET. LEV. NO.	ALTITUDE MSL (FT)	GND (FT)	GND (M)	WIND DIR (DEG)	WIND SPEED (M/S)	(KTS)	TEMP	AIR PTEMP (DEG C)	DPTEMP	AIR PRESS (MB)	AIR RH (%)	H M	INT-ERP
1	16	0.0	0.0	360	5.1	10.0	21.2	21.2	16.7	1024.7	75.0		
2	62	45.5	13.9	359	6.4	12.5	20.7	20.8	16.2	1023.1	75.5		**
3	107	91.0	27.7	358	7.7	15.0	20.1	20.3	15.7	1021.4	75.5		**
4	153	136.5	41.6	356	9.0	17.5	19.6	19.9	15.2	1019.8	75.6		**
5	198	182.0	55.5	355	10.3	20.0	19.1	19.4	14.7	1018.2	75.0		
6	325	308.8	94.1	360	9.6	18.7	18.9	19.6	15.0	1013.6	78.3		**
7	452	435.5	132.7	5	9.0	17.5	18.6	19.8	15.3	1009.1	81.1		**
8	578	562.3	171.4	9	8.4	16.2	18.4	20.0	15.7	1004.5	84.0		**
9	705	689.0	210.0	14	7.7	15.0	18.2	20.2	16.0	1000.0	87.0		
10	853	836.5	255.0	18	7.4	14.4	18.1	20.6	16.3	994.8	89.0		**
11	1000	984.0	299.9	22	7.1	13.8	18.0	21.0	16.5	989.7	91.0		
12	1078	1062.0	323.7	24	7.2	14.0	17.9	21.1	16.7	986.9	92.0		
13	1385	1369.3	417.4	33	6.4	12.5	17.7	21.9	16.7	976.2	93.9		**
14	1693	1676.7	511.0	42	5.7	11.1	17.6	22.7	16.8	965.6	95.1		**
15	2000	1984.0	604.7	51	4.9	9.6	17.4	23.5	16.8	955.2	96.0		
16	2150	2134.0	650.4	57	4.6	9.0	17.1	23.7	16.6	950.0	97.0		
17	2210	2194.0	668.7	59	4.6	9.0	17.0	23.7	16.5	948.1	97.0		
18	2674	2658.0	810.2	76	4.1	8.0	16.0	24.0	15.5	932.6	97.0	*	
19	2837	2821.0	859.8	88	3.4	6.5	16.3	24.8	15.4	927.2	94.7		**
20	3000	2984.0	909.5	100	2.6	5.1	16.6	25.6	15.4	921.8	92.0		
21	3040	3024.0	921.7	104	2.6	5.0	16.7	25.9	15.4	920.5	92.0		
22	3131	3115.5	949.6	121	2.3	4.5	16.7	26.0	14.7	917.5	88.1		**
23	3223	3207.0	977.5	137	2.1	4.0	16.7	26.2	14.0	914.5	84.0		
24	3444	3428.0	1044.9	152	1.8	3.5	16.1	26.3	13.7	907.2	85.8		**
25	3788	3772.0	1149.7	186	1.3	2.5	15.2	26.4	13.3	896.1	88.5		**
26	4000	3984.0	1214.3	221	1.0	2.0	14.8	26.5	12.4	889.5	85.0		
27	4399	4383.0	1335.9	254	1.5	3.0	14.4	27.1	9.8	876.8	73.9		**
28	4798	4782.0	1457.6	286	2.1	4.0	14.0	27.6	7.1	864.3	63.0		
29	5253	5237.0	1596.2	301	3.6	7.0	13.6	28.4	3.0	850.0	49.0		
30	6000	5984.0	1823.9	300	4.2	8.2	13.0	29.6	-5.1	827.6	28.0		
31	6922	6906.0	2104.9	302	5.1	10.0	10.9	30.8	3.0	800.0	58.0		
32	7147	7131.0	2173.5	303	5.7	11.0	10.4	31.1	3.6	793.8	63.0		
33	8679	8663.0	2640.5	306	7.2	14.0	7.4	32.6	-0.1	750.0	59.0		
34	9500	9484.0	2890.7	295	6.4	12.3	5.6	33.2	-2.5	728.0	56.9		**

* - INDICATES THE CALCULATED TOP OF THE SURFACE MIXING LAYER
** - INDICATES THAT DATA IS LINEARLY INTERPOLATED FROM INPUT METEOROLOGY

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1*************************************************************************
              ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM       PAGE    4
                         VERSION 7.08 AT  KSC
                         1334 EDT 28 APR 1997
                  launch time:  1520 EST 23 FEB 1997
      RAWINSONDE ASCENT NUMBER      0, 1948   Z 23 FEB   97  T  -0.5 HR
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----- METEOROLOGICAL RAWINSONDE DATA -----

SURFACE AIR DENSITY (GM/M**3)	1204.28
DEFAULT CALCULATED MIXING LAYER HEIGHT (M)	810.16
CLOUD COVER IN TENTHS OF CELESTIAL DOME	0.0
CLOUD CEILING (M)	9999.0

----- PLUME RISE DATA -----

EXHAUST RATE OF MATERIAL INTO GRN CLD-	(GRAMS/SEC)		5.34133E+06
TOTAL GROUND CLD MATERIAL-	(GRAMS)		5.31244E+07
HEAT OUTPUT PER GRAM-	(CALORIES)		1555.6
VEHICLE RISE HEIGHT DEFINING GROUND CLD-	(M)		199.9
VEHICLE RISE TIME PARAMETERS-	(TK=(A*Z**B)+C)	A=	0.9519
		B=	0.4429
		C=	0.0000
EXHAUST RATE OF MATERIAL INTO CONTRAIL-	(GRAMS/SEC)		5.34133E+06
CONTRAIL HEAT OUTPUT PER GRAM-	(CALORIES)		1555.6

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ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM PAGE 5
VERSION 7.08 AT KSC
1334 EDT 28 APR 1997
launch time: 1520 EST 23 FEB 1997
RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR

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----- EXHAUST CLOUD -----

MET. LAYER NO.	TOP OF LAYER (METERS)	CLOUD RISE TIME (SECONDS)	CLOUD RISE RANGE (METERS)	CLOUD RISE BEARING (DEGREES)	STABILIZED CLOUD RANGE (METERS)	STABILIZED CLOUD BEARING (DEGREES)
1	13.9	1.4	3.8	179.6	0.0	0.0
2	27.7	2.2	10.7	179.1	0.0	0.0
3	41.6	2.9	16.7	178.5	0.0	0.0
4	55.5	3.7	23.5	177.8	0.0	0.0
5	94.1	6.0	39.0	177.1	0.0	0.0
6	132.7	8.7	63.0	178.1	0.0	0.0
7	171.4	11.8	88.8	180.0	0.0	0.0
8	210.0	15.3	116.1	182.2	0.0	0.0
9	255.0	19.9	147.1	184.7	0.0	0.0
10	299.9	25.1	182.7	187.3	0.0	0.0
11	323.7	28.1	211.1	189.3	0.0	0.0
12	417.4	41.4	266.4	192.7	1569.5	205.9
13	511.0	57.3	355.7	197.9	1409.9	212.7
14	604.7	76.6	448.6	203.1	1258.7	218.4
15	650.4	87.5	517.4	206.9	1182.8	222.5
16	668.7	92.3	549.7	208.8	1165.1	224.7
17	810.2	138.7	648.2	214.4	1021.0	227.2
18	859.8	163.0	765.9	221.3	981.1	231.4
19	909.5	204.0	843.4	226.6	905.7	230.8
20	921.7	233.5 *	930.6	233.2	930.6	233.2
21	949.6	233.5 *	930.6	233.2	930.6	233.2
22	977.5	233.5 *	930.6	233.2	930.6	233.2
23	1044.9	233.5 *	930.6	233.2	930.6	233.2
24	1149.7	233.5 *	930.6	233.2	930.6	233.2
25	1214.3	233.5 *	930.6	233.2	930.6	233.2
26	1335.9	233.5 *	930.6	233.2	930.6	233.2
27	1457.6	233.5 *	930.6	233.2	930.6	233.2
28	1596.2	233.5 *	930.6	233.2	930.6	233.2
29	1823.9	233.5 *	930.6	233.2	930.6	233.2
30	2104.9	233.5 *	930.6	233.2	930.6	233.2
31	2173.5	233.5 *	930.6	233.2	930.6	233.2
32	2640.5	233.5 *	930.6	233.2	930.6	233.2
33	2890.7	233.5 *	930.6	233.2	930.6	233.2

* - INDICATES CLOUD STABILIZATION TIME WAS USED

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ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM PAGE 6

VERSION 7.08 AT KSC

1334 EDT 28 APR 1997

launch time: 1520 EST 23 FEB 1997

RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR

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----- EXHAUST CLOUD -----

CHEMICAL SPECIES = HCL

MET. LAYER NO.	TOP OF LAYER (METERS)	LAYER SOURCE STRENGTH (GRAMS)	CLOUD UPDRAFT VELOCITY (M/S)	CLOUD RADIUS (METERS)	STD. DEVIATION ALONGWIND (METERS)	MATERIAL DIST. CROSSWIND (METERS)
1	13.9	0.00000E+00	15.9	0.0	0.0	0.0
2	27.7	0.00000E+00	18.3	0.0	0.0	0.0
3	41.6	0.00000E+00	18.4	0.0	0.0	0.0
4	55.5	0.00000E+00	17.9	0.0	0.0	0.0
5	94.1	0.00000E+00	15.6	0.0	0.0	0.0
6	132.7	0.00000E+00	13.4	0.0	0.0	0.0
7	171.4	0.00000E+00	11.7	0.0	0.0	0.0
8	210.0	0.00000E+00	10.3	0.0	0.0	0.0
9	255.0	0.00000E+00	9.1	0.0	0.0	0.0
10	299.9	0.00000E+00	8.2	0.0	0.0	0.0
11	323.7	0.00000E+00	7.8	0.0	0.0	0.0
12	417.4	1.63887E+05	6.4	235.5	109.7	109.7
13	511.0	5.15401E+05	5.4	417.2	194.4	194.4
14	604.7	8.02679E+05	4.4	520.2	242.4	242.4
15	650.4	4.76267E+05	4.0	572.8	266.9	266.9
16	668.7	2.03565E+05	3.8	591.9	275.8	275.8
17	810.2	1.76430E+06	2.4	628.3	292.8	292.8
18	859.8	6.73154E+05	1.7	653.2	304.4	304.4
19	909.5	6.85041E+05	0.7	659.0	307.1	307.1
20	921.7 *	1.87063E+05	0.0	660.1	307.6	307.6
21	949.6 *	6.79765E+05	0.0	659.9	307.5	307.5
22	977.5 *	6.73152E+05	0.0	658.3	306.8	306.8
23	1044.9 *	1.58928E+06	0.0	652.2	303.9	303.9
24	1149.7 *	2.32761E+06	0.0	629.4	293.3	293.3
25	1214.3 *	1.31421E+06	0.0	591.0	275.4	275.4
26	1335.9 *	2.14308E+06	0.0	526.2	245.2	245.2
27	1457.6 *	1.59715E+06	0.0	386.6	180.2	180.2
28	1596.2 *	1.17151E+06	0.0	267.9	124.8	124.8
29	1823.9 *	1.71601E+06	0.0	199.9	93.2	93.2
30	2104.9 *	1.96076E+06	0.0	199.9	93.2	93.2
31	2173.5 *	4.55979E+05	0.0	199.9	93.2	93.2
32	2640.5 *	2.91115E+06	0.0	199.9	93.2	93.2
33	2890.7 *	1.44239E+06	0.0	199.9	93.2	93.2

* - INDICATES CLOUD STABILIZATION TIME WAS USED

----- CLOUD STABILIZATION -----

CALCULATION HEIGHT	(METERS)		920.00
STABILIZATION HEIGHT	(METERS)		920.00
STABILIZATION TIME	(SECS)		233.53
FIRST MIXING LAYER HEIGHT-	(METERS)	TOP =	810.16
		BASE=	0.00
SECOND SELECTED LAYER HEIGHT-	(METERS)	TOP =	2890.72
		BASE=	810.16
SIGMAR(AZ) AT THE SURFACE	(DEGREES)		9.4281
SIGMER(EL) AT THE SURFACE	(DEGREES)		3.1198

MET. LAYER NO.	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIRECTION (DEG)	WIND DIRECTION SHEAR (DEG)	SIGMA OF AZI ANG (DEG)	SIGMA OF ELE ANG (DEG)
1	6.02	1.29	359.38	-1.25	8.1796	3.5890
2	7.07	1.29	358.13	-1.25	6.6612	4.2038
3	8.36	1.29	356.88	-1.25	6.2432	4.4394
4	9.65	1.29	355.63	-1.25	5.9943	4.5955
5	9.97	-0.64	357.38	4.75	5.7167	4.7881
6	9.32	-0.64	2.13	4.75	5.3491	4.7850
7	8.68	-0.64	6.88	4.75	5.0311	4.5481
8	8.04	-0.64	11.63	4.75	4.7665	4.3247
9	7.56	-0.31	16.00	4.00	4.4811	4.0838
10	7.25	-0.31	20.00	4.00	4.2202	3.8635
11	7.15	0.10	23.00	2.00	3.9139	3.6049
12	6.82	-0.75	28.50	9.00	3.4125	3.1817
13	6.07	-0.75	37.50	9.00	2.7961	2.6614
14	5.32	-0.75	46.50	9.00	2.2586	2.2077
15	4.78	-0.31	54.00	6.00	1.9328	1.9252
16	4.63	0.00	58.00	2.00	1.6146	1.6146
17	4.37	-0.51	67.50	17.00	1.1964	1.1964
18	3.74	-0.75	82.00	12.00	1.0000	1.0000
19	3.00	-0.75	94.00	12.00	1.0000	1.0000
20	2.60	-0.05	102.00	4.00	1.0000	1.0000
21	2.44	-0.26	112.25	16.50	1.0000	1.0000
22	2.19	-0.26	128.75	16.50	1.0000	1.0000
23	1.93	-0.26	144.50	15.00	1.0000	1.0000
24	1.54	-0.51	169.00	34.00	1.0000	1.0000
25	1.16	-0.26	203.50	35.00	1.0000	1.0000
26	1.29	0.51	237.25	32.50	1.0000	1.0000
27	1.80	0.51	269.75	32.50	1.0000	1.0000
28	2.83	1.54	293.50	15.00	1.0000	1.0000
29	3.91	0.62	300.50	-1.00	1.0000	1.0000
30	4.68	0.93	301.00	2.00	1.0000	1.0000

----- CALCULATED METEOROLOGICAL LAYER PARAMETERS -----

MET. LAYER NO.	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIRECTION (DEG)	WIND DIRECTION SHEAR (DEG)	SIGMA OF AZI ANG (DEG)	SIGMA OF ELE ANG (DEG)
31	5.40	0.51	302.50	1.00	1.0000	1.0000
32	6.43	1.54	304.50	3.00	1.0000	1.0000
33	6.78	-0.85	300.50	-11.00	1.0000	1.0000

ALTITUDE RANGE USED IN COMPUTING TRANSITION LAYER AVERAGES
IS 255.0 TO 2890.7 METERS.

TRANSITION LAYER NUMBER- 1

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	810.16	297.15	4.12		76.00		1.0000	1.0000
LAYER-			5.41	1.15	42.05	16.84	2.4551	2.3421
BOTTOM-	0.00	294.34	5.14		360.00		9.4281	3.1198

TRANSITION LAYER NUMBER- 2

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	2890.72	306.32	6.35		295.00		1.0000	1.0000
LAYER-			3.48	3.24	299.55	14.32	1.0000	1.0000
BOTTOM-	810.16	297.15	4.12		76.00		1.0000	1.0000

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ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM PAGE 9
VERSION 7.08 AT KSC
1334 EDT 28 APR 1997
launch time: 1520 EST 23 FEB 1997
RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR

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----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 920.0 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 810.2 AND 2890.7 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
1021.4396	171.9464	19.0770	4.6214	12.8219
2001.2214	144.7041	14.0310	8.9634	18.8160
3000.1116	136.0572	10.1095	12.9079	24.8683
4000.0244	131.8640	7.4482	16.6601	30.9476
5000.0161	129.3356	5.6623	20.3118	37.0430
6000.0073	127.9512	4.4412	23.8849	43.1136
7000.0034	126.7043	3.5701	27.4392	49.2202
8000.0020	125.7712	2.9284	30.9689	55.3300
9000.0010	125.0465	2.4414	34.4815	61.4422
10000.0010	124.4672	2.0624	37.9818	67.5564
11000.0000	123.9937	1.7614	41.4731	73.6722
12000.0000	123.5993	1.5182	44.9575	79.7891
13000.0000	123.5630	1.3178	48.4209	85.8794
14000.0000	123.2757	1.1530	51.8958	91.9982
15000.0000	123.0267	1.0151	55.3672	98.1177
16000.0000	122.8089	0.8985	58.8358	104.2377
17000.0000	122.6168	0.7994	62.3021	110.3582
18000.0000	122.4461	0.7144	65.7664	116.4790
19000.0000	122.2933	0.6411	69.2291	122.6002
20000.0000	122.1559	0.5777	72.6903	128.7216
21000.0000	122.0315	0.5224	76.1504	134.8434
22000.0000	121.9185	0.4740	79.6094	140.9653
23000.0000	121.8153	0.4314	83.0675	147.0873
24000.0000	121.7207	0.3939	86.5247	153.2096
25000.0000	121.6336	0.3607	89.9813	159.3320
26000.0000	121.5533	0.3311	93.4372	165.4546
27000.0000	121.4790	0.3048	96.8926	171.5772
28000.0000	121.4099	0.2812	100.3475	177.7000
29000.0000	121.3456	0.2601	103.8019	183.8229
30000.0000	121.2856	0.2410	107.2559	189.9458
31000.0000	121.2295	0.2238	110.7096	196.0689
32000.0000	121.1768	0.2083	114.1629	202.1920
33000.0000	121.1274	0.1942	117.6159	208.3151
34000.0000	121.0809	0.1814	121.0687	214.4383
35000.0000	121.0370	0.1697	124.5212	220.5616

----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 920.0 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 810.2 AND 2890.7 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
36000.0000	120.9956	0.1590	127.9734	226.6849
37000.0000	120.9564	0.1492	131.4255	232.8083
38000.0000	120.9193	0.1403	134.8773	238.9318
39000.0000	120.8841	0.1321	138.3290	245.0552
40000.0000	120.8506	0.1245	141.7805	251.1787
41000.0000	120.8188	0.1175	145.2319	257.3022
42000.0000	120.7885	0.1110	148.6831	263.4258
43000.0000	120.7596	0.1051	152.1341	269.5494
44000.0000	120.7320	0.0995	155.5851	275.6730
45000.0000	120.7057	0.0944	159.0359	281.7967
46000.0000	120.6804	0.0896	162.4866	287.9203
47000.0000	120.6563	0.0852	165.9372	294.0440
48000.0000	120.6332	0.0811	169.3878	300.1677
49000.0000	120.6110	0.0772	172.8382	306.2915
50000.0000	120.5897	0.0736	176.2885	312.4152
51000.0000	120.5692	0.0702	179.7388	318.5390
52000.0000	120.5495	0.0671	183.1890	324.6628
53000.0000	120.5306	0.0641	186.6391	330.7866
54000.0000	120.5124	0.0613	190.0891	336.9104
55000.0000	120.4948	0.0587	193.5391	343.0343
56000.0000	120.4779	0.0562	196.9890	349.1581
57000.0000	120.4615	0.0539	200.4389	355.2820
58000.0000	120.4457	0.0518	203.8887	361.4059
59000.0000	120.4305	0.0497	207.3385	367.5297
60000.0000	120.4157	0.0478	210.7881	373.6536

	RANGE	BEARING
19.077 IS THE MAXIMUM PEAK CONCENTRATION	1021.4	171.9

1***

ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM PAGE 11
VERSION 7.08 AT KSC
1334 EDT 28 APR 1997
launch time: 1520 EST 23 FEB 1997
RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR

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----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 920.0 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 810.2 AND 2890.7 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	60.0 MIN. MEAN CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
1021.4396	171.9464	1.2980	4.6214	12.8219
2001.2214	144.7041	1.1771	8.9634	18.8160
3000.1116	136.0572	1.0540	12.9079	24.8683
4000.0244	131.8640	0.9444	16.6601	30.9476
5000.0161	129.3356	0.8521	20.3118	37.0430
6000.0073	127.9512	0.7759	23.8849	43.1136
7000.0034	126.7043	0.7122	27.4392	49.2202
8000.0020	125.7712	0.6575	30.9689	55.3300
9000.0010	125.0465	0.6098	34.4815	61.4422
10000.0010	124.4672	0.5674	37.9818	67.5564
11000.0000	123.9937	0.5295	41.4731	73.6722
12000.0000	123.5993	0.4951	44.9575	79.7891
13000.0000	123.5630	0.4632	48.4209	85.8794
14000.0000	123.2757	0.4347	51.8958	91.9982
15000.0000	123.0267	0.4084	55.3672	98.1177
16000.0000	122.8089	0.3839	58.8358	104.2377
17000.0000	122.6168	0.3612	62.3021	110.3582
18000.0000	122.4461	0.3401	65.7664	116.4790
19000.0000	122.2933	0.3202	69.2291	122.6002
20000.0000	122.1559	0.3016	72.6903	128.7216
21000.0000	122.0315	0.2842	76.1504	134.8434
22000.0000	121.9185	0.2679	79.6094	140.9653
23000.0000	121.8153	0.2526	83.0675	147.0873
24000.0000	121.7207	0.2382	86.5247	153.2096
25000.0000	121.6336	0.2247	89.9813	159.3320
26000.0000	121.5533	0.2121	93.4372	165.4546
27000.0000	121.4790	0.2002	96.8926	171.5772
28000.0000	121.4099	0.1892	100.3475	177.7000
29000.0000	121.3456	0.1788	103.8019	183.8229
30000.0000	121.2856	0.1691	107.2559	189.9458
31000.0000	121.2295	0.1600	110.7096	196.0689
32000.0000	121.1768	0.1515	114.1629	202.1920
33000.0000	121.1274	0.1436	117.6159	208.3151
34000.0000	121.0809	0.1361	121.0687	214.4383

----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 920.0 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 810.2 AND 2890.7 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	60.0 MIN. MEAN CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
35000.0000	121.0370	0.1291	124.5212	220.5616
36000.0000	120.9956	0.1226	127.9734	226.6849
37000.0000	120.9564	0.1165	131.4255	232.8083
38000.0000	120.9193	0.1107	134.8773	238.9318
39000.0000	120.8841	0.1054	138.3290	245.0552
40000.0000	120.8506	0.1003	141.7805	251.1787
41000.0000	120.8188	0.0956	145.2319	257.3022
42000.0000	120.7885	0.0911	148.6831	263.4258
43000.0000	120.7596	0.0869	152.1341	269.5494
44000.0000	120.7320	0.0830	155.5851	275.6730
45000.0000	120.7057	0.0793	159.0359	281.7967
46000.0000	120.6804	0.0758	162.4866	287.9203
47000.0000	120.6563	0.0725	165.9372	294.0440
48000.0000	120.6332	0.0694	169.3878	300.1677
49000.0000	120.6110	0.0665	172.8382	306.2915
50000.0000	120.5897	0.0638	176.2885	312.4152
51000.0000	120.5692	0.0612	179.7388	318.5390
52000.0000	120.5495	0.0587	183.1890	324.6628
53000.0000	120.5306	0.0564	186.6391	330.7866
54000.0000	120.5124	0.0542	190.0891	336.9104
55000.0000	120.4948	0.0521	193.5391	343.0343
56000.0000	120.4779	0.0501	196.9890	349.1581
57000.0000	120.4615	0.0482	200.4389	355.2820
58000.0000	120.4457	0.0464	203.8887	361.4059
59000.0000	120.4305	0.0447	207.3385	367.5297
60000.0000	120.4157	0.0431	210.7881	373.6536

	RANGE	BEARING
1.298 IS THE MAXIMUM 60.0 MIN. MEAN CONCENTRATION	1021.4	171.9

*** REEDM HAS TERMINATED

3.2 REEDM Surface Impact Report for T-0.53h Run

The following 11 pages contain the detailed REEDM report for the T-0.53h calculations relevant to the surface impact (i.e., 0 m AGL) of the exhaust cloud. The analyst accepted the default settings for all parameters including the heights for the first and second mixing layers. The first page of the REEDM output contains trouble shooting error codes that are beyond the scope of this report, and, therefore, that page is not included in this appendix. The REEDM report is presented in a different font so that the column headings align with the columns.

REEDM reports heights for the exhaust cloud as height above ground level (AGL). For the rawinsonde data, REEDM assumes 0 m AGL = 4.9 m MSL = the height of the rawinsonde release site. However, for the Titan IV exhaust cloud, one assumes 0 m AGL = 7 m MSL = the height of SLC-40.

VERSION 7.08 AT KSC
1645 EDT 1 JUL 1997
launch time: 1520 EST 23 FEB 1997
RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR
****

----- PROGRAM OPTIONS -----

MODEL		CONCENTRATION
RUN TYPE		OPERATIONAL
WIND-FIELD TERRAIN EFFECTS MODEL		NONE
LAUNCH VEHICLE		TITAN IVB SRMU
LAUNCH TYPE		NORMAL
LAUNCH COMPLEX NUMBER		40
TURBULENCE PARAMETERS ARE DETERMINED FROM		CLIMATOLOGICAL DATA
SURFACE CHEMISTRY MODEL		absorption coefficient
SPECIES SURFACE FACTOR	HCL	0.000
CLOUD SHAPE		ELLIPTICAL
CALCULATION HEIGHT		SURFACE
PROPELLANT TEMPERATURE (DEG. C)		19.59
CONCENTRATION AVERAGING TIME (SEC.)		3600.00
mixing layer reflection coefficient (RNG- 0 TO 1,no reflection=0)		1.0000
DIFFUSION COEFFICIENTS	LATERAL	1.0000
	VERTICAL	1.0000
VEHICLE AIR ENTRAINMENT PARAMETER	GAMMAE	0.6400
DOWNWIND EXPANSION DISTANCE (METERS)	LATERAL	100.00
	VERTICAL	100.00

----- DATA FILES -----

INPUT FILES

RAWINSONDE FILE	k24_1948.raw
DATA BASE FILE	rdmbase.ksc

OUTPUT FILES

PRINT FILE	k2481948.sur
PLOT FILE	k2481948.sup

1***

ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM PAGE 3
VERSION 7.08 AT KSC
1645 EDT 1 JUL 1997
launch time: 1520 EST 23 FEB 1997
RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR

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----- METEOROLOGICAL RAWINSONDE DATA -----

RAWINSONDE MSS/MSS
TIME- 1948 Z DATE- 23 FEB 97
ASCENT NUMBER 0

----- T -0.5 HR SOUNDING -----

MET. LEV. NO.	ALTITUDE MSL (FT)	GND (FT)	GND (M)	WIND DIR (DEG)	WIND SPEED (M/S)	(KTS)	TEMP	AIR PTEMP (DEG C)	DPTEMP	AIR PRESS (MB)	AIR RH (%)	H M	INT-ERP
1	16	0.0	0.0	360	5.1	10.0	21.2	21.2	16.7	1024.7	75.0		
2	62	45.5	13.9	359	6.4	12.5	20.7	20.8	16.2	1023.1	75.5		**
3	107	91.0	27.7	358	7.7	15.0	20.1	20.3	15.7	1021.4	75.5		**
4	153	136.5	41.6	356	9.0	17.5	19.6	19.9	15.2	1019.8	75.6		**
5	198	182.0	55.5	355	10.3	20.0	19.1	19.4	14.7	1018.2	75.0		
6	325	308.8	94.1	360	9.6	18.7	18.9	19.6	15.0	1013.6	78.3		**
7	452	435.5	132.7	5	9.0	17.5	18.6	19.8	15.3	1009.1	81.1		**
8	578	562.3	171.4	9	8.4	16.2	18.4	20.0	15.7	1004.5	84.0		**
9	705	689.0	210.0	14	7.7	15.0	18.2	20.2	16.0	1000.0	87.0		
10	853	836.5	255.0	18	7.4	14.4	18.1	20.6	16.3	994.8	89.0		**
11	1000	984.0	299.9	22	7.1	13.8	18.0	21.0	16.5	989.7	91.0		
12	1078	1062.0	323.7	24	7.2	14.0	17.9	21.1	16.7	986.9	92.0		
13	1385	1369.3	417.4	33	6.4	12.5	17.7	21.9	16.7	976.2	93.9		**
14	1693	1676.7	511.0	42	5.7	11.1	17.6	22.7	16.8	965.6	95.1		**
15	2000	1984.0	604.7	51	4.9	9.6	17.4	23.5	16.8	955.2	96.0		
16	2150	2134.0	650.4	57	4.6	9.0	17.1	23.7	16.6	950.0	97.0		
17	2210	2194.0	668.7	59	4.6	9.0	17.0	23.7	16.5	948.1	97.0		
18	2674	2658.0	810.2	76	4.1	8.0	16.0	24.0	15.5	932.6	97.0	*	
19	2837	2821.0	859.8	88	3.4	6.5	16.3	24.8	15.4	927.2	94.7		**
20	3000	2984.0	909.5	100	2.6	5.1	16.6	25.6	15.4	921.8	92.0		
21	3040	3024.0	921.7	104	2.6	5.0	16.7	25.9	15.4	920.5	92.0		
22	3131	3115.5	949.6	121	2.3	4.5	16.7	26.0	14.7	917.5	88.1		**
23	3223	3207.0	977.5	137	2.1	4.0	16.7	26.2	14.0	914.5	84.0		
24	3444	3428.0	1044.9	152	1.8	3.5	16.1	26.3	13.7	907.2	85.8		**
25	3788	3772.0	1149.7	186	1.3	2.5	15.2	26.4	13.3	896.1	88.5		**
26	4000	3984.0	1214.3	221	1.0	2.0	14.8	26.5	12.4	889.5	85.0		
27	4399	4383.0	1335.9	254	1.5	3.0	14.4	27.1	9.8	876.8	73.9		**
28	4798	4782.0	1457.6	286	2.1	4.0	14.0	27.6	7.1	864.3	63.0		
29	5253	5237.0	1596.2	301	3.6	7.0	13.6	28.4	3.0	850.0	49.0		
30	6000	5984.0	1823.9	300	4.2	8.2	13.0	29.6	-5.1	827.6	28.0		
31	6922	6906.0	2104.9	302	5.1	10.0	10.9	30.8	3.0	800.0	58.0		
32	7147	7131.0	2173.5	303	5.7	11.0	10.4	31.1	3.6	793.8	63.0		
33	8679	8663.0	2640.5	306	7.2	14.0	7.4	32.6	-0.1	750.0	59.0		
34	9500	9484.0	2890.7	295	6.4	12.3	5.6	33.2	-2.5	728.0	56.9		**

* - INDICATES THE CALCULATED TOP OF THE SURFACE MIXING LAYER
** - INDICATES THAT DATA IS LINEARLY INTERPOLATED FROM INPUT METEOROLOGY

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1***************************************************************************
             ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM        PAGE    4
                         VERSION 7.08 AT  KSC
                         1645 EDT  1 JUL 1997
                  launch time:  1520 EST 23 FEB 1997
     RAWINSONDE ASCENT NUMBER       0, 1948    Z 23 FEB   97  T  -0.5 HR
***************************************************************************

               ----- METEOROLOGICAL RAWINSONDE DATA -----


  SURFACE AIR DENSITY (GM/M**3)                                       1204.28
  DEFAULT CALCULATED MIXING LAYER HEIGHT (M)                           810.16
  CLOUD COVER IN TENTHS OF CELESTIAL DOME                                 0.0
  CLOUD CEILING (M)                                                    9999.0
                        ----- PLUME RISE DATA -----

 EXHAUST RATE OF MATERIAL INTO GRN CLD-    (GRAMS/SEC)          5.34133E+06
 TOTAL GROUND CLD MATERIAL-                (GRAMS)              5.31244E+07
 HEAT OUTPUT PER GRAM-                     (CALORIES)                1555.6
 VEHICLE RISE HEIGHT DEFINING GROUND CLD-  (M)                        199.9
 VEHICLE RISE TIME PARAMETERS-             (TK=(A*Z**B)+C)  A=       0.9519
                                                            B=       0.4429
                                                            C=       0.0000
 EXHAUST RATE OF MATERIAL INTO CONTRAIL-   (GRAMS/SEC)          5.34133E+06
 CONTRAIL HEAT OUTPUT PER GRAM-            (CALORIES)                1555.6
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1*************************************************************************
                  ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM        PAGE    5
                              VERSION 7.08 AT  KSC
                              1645 EDT   1 JUL 1997
                         launch time:  1520 EST 23 FEB 1997
        RAWINSONDE ASCENT NUMBER        0, 1948    Z 23 FEB    97  T  -0.5 HR
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----- EXHAUST CLOUD -----

MET. LAYER NO.	TOP OF LAYER (METERS)	CLOUD RISE TIME (SECONDS)	CLOUD RISE RANGE (METERS)	CLOUD RISE BEARING (DEGREES)	STABILIZED CLOUD RANGE (METERS)	STABILIZED CLOUD BEARING (DEGREES)
1	13.9	1.4	3.8	179.6	0.0	0.0
2	27.7	2.2	10.7	179.1	0.0	0.0
3	41.6	2.9	16.7	178.5	0.0	0.0
4	55.5	3.7	23.5	177.8	0.0	0.0
5	94.1	6.0	39.0	177.1	0.0	0.0
6	132.7	8.7	63.0	178.1	0.0	0.0
7	171.4	11.8	88.8	180.0	0.0	0.0
8	210.0	15.3	116.1	182.2	0.0	0.0
9	255.0	19.9	147.1	184.7	0.0	0.0
10	299.9	25.1	182.7	187.3	0.0	0.0
11	323.7	28.1	211.1	189.3	0.0	0.0
12	417.4	41.4	266.4	192.7	1569.5	205.9
13	511.0	57.3	355.7	197.9	1409.9	212.7
14	604.7	76.6	448.6	203.1	1258.7	218.4
15	650.4	87.5	517.4	206.9	1182.8	222.5
16	668.7	92.3	549.7	208.8	1165.1	224.7
17	810.2	138.7	648.2	214.4	1021.0	227.2
18	859.8	163.0	765.9	221.3	981.1	231.4
19	909.5	204.0	843.4	226.6	905.7	230.8
20	921.7	233.5 *	930.6	233.2	930.6	233.2
21	949.6	233.5 *	930.6	233.2	930.6	233.2
22	977.5	233.5 *	930.6	233.2	930.6	233.2
23	1044.9	233.5 *	930.6	233.2	930.6	233.2
24	1149.7	233.5 *	930.6	233.2	930.6	233.2
25	1214.3	233.5 *	930.6	233.2	930.6	233.2
26	1335.9	233.5 *	930.6	233.2	930.6	233.2
27	1457.6	233.5 *	930.6	233.2	930.6	233.2
28	1596.2	233.5 *	930.6	233.2	930.6	233.2
29	1823.9	233.5 *	930.6	233.2	930.6	233.2
30	2104.9	233.5 *	930.6	233.2	930.6	233.2
31	2173.5	233.5 *	930.6	233.2	930.6	233.2
32	2640.5	233.5 *	930.6	233.2	930.6	233.2
33	2890.7	233.5 *	930.6	233.2	930.6	233.2

* - INDICATES CLOUD STABILIZATION TIME WAS USED

1**

ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM PAGE 6
VERSION 7.08 AT KSC
1645 EDT 1 JUL 1997
launch time: 1520 EST 23 FEB 1997
RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR

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----- EXHAUST CLOUD -----

CHEMICAL SPECIES = HCL

MET. LAYER NO.	TOP OF LAYER (METERS)	LAYER SOURCE STRENGTH (GRAMS)	CLOUD UPDRAFT VELOCITY (M/S)	CLOUD RADIUS (METERS)	STD. DEVIATION MATERIAL DIST. ALONGWIND (METERS)	CROSSWIND (METERS)
1	13.9	0.00000E+00	15.9	0.0	0.0	0.0
2	27.7	0.00000E+00	18.3	0.0	0.0	0.0
3	41.6	0.00000E+00	18.4	0.0	0.0	0.0
4	55.5	0.00000E+00	17.9	0.0	0.0	0.0
5	94.1	0.00000E+00	15.6	0.0	0.0	0.0
6	132.7	0.00000E+00	13.4	0.0	0.0	0.0
7	171.4	0.00000E+00	11.7	0.0	0.0	0.0
8	210.0	0.00000E+00	10.3	0.0	0.0	0.0
9	255.0	0.00000E+00	9.1	0.0	0.0	0.0
10	299.9	0.00000E+00	8.2	0.0	0.0	0.0
11	323.7	0.00000E+00	7.8	0.0	0.0	0.0
12	417.4	1.63887E+05	6.4	235.5	109.7	109.7
13	511.0	5.15401E+05	5.4	417.2	194.4	194.4
14	604.7	8.02679E+05	4.4	520.2	242.4	242.4
15	650.4	4.76267E+05	4.0	572.8	266.9	266.9
16	668.7	2.03565E+05	3.8	591.9	275.8	275.8
17	810.2	1.76430E+06	2.4	628.3	292.8	292.8
18	859.8	6.73154E+05	1.7	653.2	304.4	304.4
19	909.5	6.85041E+05	0.7	659.0	307.1	307.1
20	921.7 *	1.87063E+05	0.0	660.1	307.6	307.6
21	949.6 *	6.79765E+05	0.0	659.9	307.5	307.5
22	977.5 *	6.73152E+05	0.0	658.3	306.8	306.8
23	1044.9 *	1.58928E+06	0.0	652.2	303.9	303.9
24	1149.7 *	2.32761E+06	0.0	629.4	293.3	293.3
25	1214.3 *	1.31421E+06	0.0	591.0	275.4	275.4
26	1335.9 *	2.14308E+06	0.0	526.2	245.2	245.2
27	1457.6 *	1.59715E+06	0.0	386.6	180.2	180.2
28	1596.2 *	1.17151E+06	0.0	267.9	124.8	124.8
29	1823.9 *	1.71601E+06	0.0	199.9	93.2	93.2
30	2104.9 *	1.96076E+06	0.0	199.9	93.2	93.2
31	2173.5 *	4.55979E+05	0.0	199.9	93.2	93.2
32	2640.5 *	2.91115E+06	0.0	199.9	93.2	93.2
33	2890.7 *	1.44239E+06	0.0	199.9	93.2	93.2

* - INDICATES CLOUD STABILIZATION TIME WAS USED

1***
ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM PAGE 7
VERSION 7.08 AT KSC
1645 EDT 1 JUL 1997
launch time: 1520 EST 23 FEB 1997
RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR
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----- CLOUD STABILIZATION -----

CALCULATION HEIGHT	(METERS)		0.00
STABILIZATION HEIGHT	(METERS)		920.00
STABILIZATION TIME	(SECS)		233.53
FIRST MIXING LAYER HEIGHT-	(METERS)	TOP =	810.16
		BASE=	0.00
SECOND SELECTED LAYER HEIGHT-	(METERS)	TOP =	2890.72
		BASE=	810.16
SIGMAR(AZ) AT THE SURFACE	(DEGREES)		9.4281
SIGMER(EL) AT THE SURFACE	(DEGREES)		3.1198

MET. LAYER NO.	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIRECTION (DEG)	WIND DIRECTION SHEAR (DEG)	SIGMA OF AZI ANG (DEG)	SIGMA OF ELE ANG (DEG)
1	6.02	1.29	359.38	-1.25	8.1796	3.5890
2	7.07	1.29	358.13	-1.25	6.6612	4.2038
3	8.36	1.29	356.88	-1.25	6.2432	4.4394
4	9.65	1.29	355.63	-1.25	5.9943	4.5955
5	9.97	-0.64	357.38	4.75	5.7167	4.7881
6	9.32	-0.64	2.13	4.75	5.3491	4.7850
7	8.68	-0.64	6.88	4.75	5.0311	4.5481
8	8.04	-0.64	11.63	4.75	4.7665	4.3247
9	7.56	-0.31	16.00	4.00	4.4811	4.0838
10	7.25	-0.31	20.00	4.00	4.2202	3.8635
11	7.15	0.10	23.00	2.00	3.9139	3.6049
12	6.82	-0.75	28.50	9.00	3.4125	3.1817
13	6.07	-0.75	37.50	9.00	2.7961	2.6614
14	5.32	-0.75	46.50	9.00	2.2586	2.2077
15	4.78	-0.31	54.00	6.00	1.9328	1.9252
16	4.63	0.00	58.00	2.00	1.6146	1.6146
17	4.37	-0.51	67.50	17.00	1.1964	1.1964
18	3.74	-0.75	82.00	12.00	1.0000	1.0000
19	3.00	-0.75	94.00	12.00	1.0000	1.0000
20	2.60	-0.05	102.00	4.00	1.0000	1.0000
21	2.44	-0.26	112.25	16.50	1.0000	1.0000
22	2.19	-0.26	128.75	16.50	1.0000	1.0000
23	1.93	-0.26	144.50	15.00	1.0000	1.0000
24	1.54	-0.51	169.00	34.00	1.0000	1.0000
25	1.16	-0.26	203.50	35.00	1.0000	1.0000
26	1.29	0.51	237.25	32.50	1.0000	1.0000
27	1.80	0.51	269.75	32.50	1.0000	1.0000
28	2.83	1.54	293.50	15.00	1.0000	1.0000
29	3.91	0.62	300.50	-1.00	1.0000	1.0000
30	4.68	0.93	301.00	2.00	1.0000	1.0000

----- CALCULATED METEOROLOGICAL LAYER PARAMETERS -----

MET. LAYER NO.	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIRECTION (DEG)	WIND DIRECTION SHEAR (DEG)	SIGMA OF AZI ANG (DEG)	SIGMA OF ELE ANG (DEG)
31	5.40	0.51	302.50	1.00	1.0000	1.0000
32	6.43	1.54	304.50	3.00	1.0000	1.0000
33	6.78	-0.85	300.50	-11.00	1.0000	1.0000

ALTITUDE RANGE USED IN COMPUTING TRANSITION LAYER AVERAGES
IS 0.0 TO 1596.2 METERS.

TRANSITION LAYER NUMBER- 1

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	810.16	297.15	4.12		76.00		1.0000	1.0000
LAYER-			6.03	1.85	26.58	22.12	3.3836	2.9986
BOTTOM-	0.00	294.34	5.14		360.00		9.4281	3.1198

TRANSITION LAYER NUMBER- 2

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	2890.72	306.32	6.35		295.00		1.0000	1.0000
LAYER-			0.45	1.13	206.69	78.05	1.0000	1.0000
BOTTOM-	810.16	297.15	4.12		76.00		1.0000	1.0000

VERSION 7.08 AT KSC
1645 EDT 1 JUL 1997
launch time: 1520 EST 23 FEB 1997
RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR
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----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 810.2 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
4000.0251	206.7796	0.0498	6.5116	12.6337
5000.1226	207.5074	0.2574	9.0826	15.5114
6000.0000	207.9543	0.4908	11.6343	18.4155
7000.0000	208.2618	0.6526	14.1708	21.3364
8000.0000	208.3016	0.7344	16.7012	24.2750
9000.0000	208.0010	0.7549	19.2301	27.2305
10000.0000	208.2054	0.7342	21.7502	30.1899
11000.0000	208.0127	0.6900	24.2724	33.1629
12000.0000	207.8520	0.6339	26.7926	36.1424
13000.0000	207.7160	0.5742	29.3113	39.1270
14000.0000	207.5995	0.5161	31.8287	42.1160
15000.0000	207.4985	0.4621	34.3451	45.1086
16000.0000	207.4101	0.4137	36.8608	48.1042
17000.0000	207.3321	0.3709	39.3759	51.1023
18000.0000	207.2628	0.3336	41.8905	54.1026
19000.0000	207.2007	0.3011	44.4047	57.1048
20000.0000	207.6132	0.2729	46.9127	60.1017
21000.0000	207.5638	0.2483	49.4263	63.1069
22000.0000	207.5190	0.2268	51.9396	66.1134
23000.0000	207.4780	0.2079	54.4527	69.1209
24000.0000	207.4404	0.1913	56.9655	72.1294
25000.0000	207.4058	0.1765	59.4783	75.1386
26000.0000	207.3739	0.1634	61.9908	78.1487
27000.0000	207.3444	0.1517	64.5033	81.1594
28000.0000	207.3170	0.1411	67.0156	84.1707
29000.0000	207.2914	0.1317	69.5278	87.1825
30000.0000	207.2676	0.1231	72.0399	90.1948
31000.0000	207.2453	0.1153	74.5520	93.2075
32000.0000	207.2244	0.1083	77.0639	96.2206
33000.0000	207.2047	0.1019	79.5758	99.2341
34000.0000	207.1862	0.0960	82.0876	102.2479
35000.0000	207.1688	0.0906	84.5994	105.2620
36000.0000	207.1524	0.0857	87.1111	108.2764
37000.0000	207.1368	0.0811	89.6228	111.2910
38000.0000	207.1220	0.0769	92.1344	114.3059

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1*************************************************************************
          ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM         PAGE   10
                        VERSION 7.08 AT  KSC
                        1645 EDT  1 JUL 1997
                 launch time:  1520 EST 23 FEB 1997
     RAWINSONDE ASCENT NUMBER        0, 1948    Z 23 FEB    97  T  -0.5 HR
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----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 810.2 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
39000.0000	207.1080	0.0730	94.6460	117.3210
40000.0000	207.0948	0.0694	97.1576	120.3363
41000.0000	207.0821	0.0661	99.6691	123.3518
42000.0000	207.0701	0.0630	102.1806	126.3674
43000.0000	207.0586	0.0601	104.6920	129.3832
44000.0000	207.0476	0.0574	107.2035	132.3992
45000.0000	207.0372	0.0549	109.7149	135.4153
46000.0000	207.0271	0.0525	112.2262	138.4315
47000.0000	207.0175	0.0503	114.7376	141.4478
48000.0000	207.0084	0.0482	117.2489	144.4643
49000.0000	206.9995	0.0463	119.7602	147.4809
50000.0000	206.9911	0.0444	122.2715	150.4975
51000.0000	206.9829	0.0427	124.7828	153.5143
52000.0000	206.9751	0.0411	127.2941	156.5312
53000.0000	206.9676	0.0395	129.8053	159.5481
54000.0000	206.9604	0.0381	132.3166	162.5651
55000.0000	206.9534	0.0367	134.8278	165.5822
56000.0000	206.9466	0.0354	137.3390	168.5994
57000.0000	206.9401	0.0342	139.8502	171.6167
58000.0000	206.9339	0.0330	142.3614	174.6339
59000.0000	206.9278	0.0319	144.8725	177.6513
60000.0000	206.9220	0.0308	147.3837	180.6687

	RANGE	BEARING
0.755 IS THE MAXIMUM PEAK CONCENTRATION	9000.0	208.0

launch time: 1520 EST 23 FEB 1997
RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR
****

----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 810.2 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	60.0 MIN. MEAN CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
4000.2095	207.1627	0.0010	6.5116	12.6337
5000.0000	207.9094	0.0069	9.0826	15.5114
6000.0000	207.9543	0.0161	11.6343	18.4155
7000.0000	208.2618	0.0249	14.1708	21.3364
8000.0000	208.3016	0.0316	16.7012	24.2750
9000.0000	208.0010	0.0360	19.2301	27.2305
10000.0000	208.2054	0.0383	21.7502	30.1899
11000.0000	208.0127	0.0391	24.2724	33.1629
12000.0000	207.8520	0.0387	26.7926	36.1424
13000.0000	207.7160	0.0376	29.3113	39.1270
14000.0000	207.5995	0.0362	31.8287	42.1160
15000.0000	207.4985	0.0345	34.3451	45.1086
16000.0000	207.4101	0.0328	36.8608	48.1042
17000.0000	207.3321	0.0311	39.3759	51.1023
18000.0000	207.2628	0.0295	41.8905	54.1026
19000.0000	207.2007	0.0280	44.4047	57.1048
20000.0000	207.6132	0.0267	46.9127	60.1017
21000.0000	207.5638	0.0255	49.4263	63.1069
22000.0000	207.5190	0.0243	51.9396	66.1134
23000.0000	207.4780	0.0233	54.4527	69.1209
24000.0000	207.4404	0.0223	56.9655	72.1294
25000.0000	207.4058	0.0215	59.4783	75.1386
26000.0000	207.3739	0.0207	61.9908	78.1487
27000.0000	207.3444	0.0199	64.5033	81.1594
28000.0000	207.3170	0.0192	67.0156	84.1707
29000.0000	207.2914	0.0185	69.5278	87.1825
30000.0000	207.2676	0.0179	72.0399	90.1948
31000.0000	207.2453	0.0174	74.5520	93.2075
32000.0000	207.2244	0.0168	77.0639	96.2206
33000.0000	207.2047	0.0163	79.5758	99.2341
34000.0000	207.1862	0.0158	82.0876	102.2479
35000.0000	207.1688	0.0154	84.5994	105.2620
36000.0000	207.1524	0.0150	87.1111	108.2764
37000.0000	207.1368	0.0146	89.6228	111.2910

VERSION 7.08 AT KSC
1645 EDT 1 JUL 1997
launch time: 1520 EST 23 FEB 1997
RAWINSONDE ASCENT NUMBER 0, 1948 Z 23 FEB 97 T -0.5 HR
****

----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 810.2 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	60.0 MIN. MEAN CONCEN- TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
38000.0000	207.1220	0.0142	92.1344	114.3059
39000.0000	207.1080	0.0138	94.6460	117.3210
40000.0000	207.0948	0.0135	97.1576	120.3363
41000.0000	207.0821	0.0132	99.6691	123.3518
42000.0000	207.0701	0.0128	102.1806	126.3674
43000.0000	207.0586	0.0126	104.6920	129.3832
44000.0000	207.0476	0.0123	107.2035	132.3992
45000.0000	207.0372	0.0120	109.7149	135.4153
46000.0000	207.0271	0.0117	112.2262	138.4315
47000.0000	207.0175	0.0115	114.7376	141.4478
48000.0000	207.0084	0.0113	117.2489	144.4643
49000.0000	206.9995	0.0110	119.7602	147.4809
50000.0000	206.9911	0.0108	122.2715	150.4975
51000.0000	206.9829	0.0106	124.7828	153.5143
52000.0000	206.9751	0.0104	127.2941	156.5312
53000.0000	206.9676	0.0102	129.8053	159.5481
54000.0000	206.9604	0.0100	132.3166	162.5651
55000.0000	206.9534	0.0098	134.8278	165.5822
56000.0000	206.9466	0.0097	137.3390	168.5994
57000.0000	206.9401	0.0095	139.8502	171.6167
58000.0000	206.9339	0.0093	142.3614	174.6339
59000.0000	206.9278	0.0092	144.8725	177.6513
60000.0000	206.9220	0.0090	147.3837	180.6687

	RANGE	BEARING
0.039 IS THE MAXIMUM 60.0 MIN. MEAN CONCENTRATION	11000.0	208.0

*** REEDM HAS TERMINATED

Appendix B—Meteorological Data for the #K24 Mission

This Appendix contains two types of meteorological data recorded at several points on base before and after the #K24 launch, which occurred at 1520 EST (2020Z):

Rawinsonde Data

This data was taken on a rawinsonde balloon launched at 1948Z (T-32 min). This data was used as an input to the REEDM 7.08 run by R. N. Abernathy, and was provided by ACTA Inc.

Meteorological Tower Data

This data was taken at a series of towers on and adjacent to Cape Canaveral AFS, located at the noted latitude and longitude. Data was taken every 15 min beginning at 2015Z (T-5 min) until 2035Z (T+15 min). Data is taken at the elevation Z, in feet, above tower base, and includes wind direction, DIR, speed, SPD in knots, temperature, T, in °F, and dew point, TD, in °F.

RS010541948
TEST NBR A1302 W9/R3 2550
RAWINSONDE MSS/MSS
CAPE CANAVERAL AFS, FLORIDA
1948Z 23 FEB 97

ALT GEOMFT	DIR DEG	SPD KTS	SHR /SEC	TEMP DEG C	DPT DEG C	PRESS MBS	RH PCT	ABHUM G/M3	DENSITY G/M3	I/R N	V/S KTS	VPS MBS	PW MM
16	360	10.0	.000	21.2	16.7	1024.70	75	13.96	1204.28	352	671	18.96	0
1000	22	13.8	.010	18.0	16.5	989.66	91	13.99	1175.82	347	667	18.80	4
2000	51	9.6	.012	17.4	16.8	955.19	96	14.28	1136.72	340	667	19.14	8
3000	100	5.1	.012	16.6	15.4	921.80	92	13.07	1100.27	325	666	17.48	12
4000	221	2.0	.011	14.8	12.4	889.47	85	10.87	1069.34	305	664	14.45	16
5000	298	5.4	.009	13.8	6.7	858.07	62	7.42	1037.28	277	662	9.83	19
6000	300	8.2	.005	13.0	-5.1	827.61	28	3.18	1005.83	244	660	4.20	20
7000	303	10.4	.004	10.8	3.2	798.08	60	5.86	975.68	254	658	7.68	22
8000	309	15.0	.008	8.8	3.0	769.43	67	5.83	947.17	247	656	7.59	23
9000	303	13.7	.003	6.8	-1.5	741.60	55	4.24	920.29	232	653	5.48	25
10000	287	11.0	.007	4.5	-3.4	714.57	56	3.71	894.31	223	650	4.75	26
11000	271	9.9	.005	2.4	-7.7	688.30	47	2.71	868.52	211	648	3.44	27
12000	262	10.5	.003	.5	-11.8	662.81	40	2.02	842.64	201	645	2.55	28
13000	252	14.3	.007	-.5	-20.1	638.12	22	1.00	814.80	188	644	1.26	28
14000	255	18.7	.008	-2.0	-14.5	614.25	38	1.62	788.22	186	642	2.03	29
15000	252	20.7	.004	-4.0	-7.5	591.14	77	2.81	763.42	188	640	3.50	29
16000	246	23.8	.006	-5.5	-9.7	568.77	72	2.37	738.82	180	638	2.92	30
17000	244	27.6	.007	-6.9	-10.7	547.13	75	2.22	714.45	174	637	2.73	31
18000	247	32.4	.008	-9.1	-14.0	526.19	68	1.70	693.25	166	634	2.07	31
19000	246	34.3	.004	-10.7	-26.1	505.88	28	.62	671.25	154	632	.75	32
20000	241	31.7	.007	-11.6	-31.7	486.24	17	.35	647.34	147	631	.43	32
21000	245	31.8	.004	-13.1	-33.0	467.30	17	.31	625.96	142	629	.38	32
22000	254	34.0	.009	-15.5	-34.7	448.95	17	.27	606.85	137	626	.32	32
23000	259	39.0	.010	-17.5	-36.3	431.18	17	.23	587.48	132	623	.27	32
24000	256	44.4	.010	-18.2	-37.3	414.01	17	.21	565.55	127	623	.24	32
25000	251	48.8	.011	-19.1	-37.8	397.51	17	.20	545.02	123	621	.23	32
26000	248	50.2	.005	-21.4	-38.0	381.55	21	.20	527.81	119	619	.23	32
27000	247	50.7	.001	-24.1	-39.5	366.09	22	.17	512.00	115	615	.19	32
28000	247	52.2	.003	-26.6	-42.6	351.09	20	.12	496.07	111	612	.14	32
29000	247	54.2	.003	-29.4	-44.9	336.56	20	.10	481.02	108	609	.11	32
30000	246	55.2	.002	-32.1	-46.6	322.47	22	.08	466.08	104	605	.09	32
31000	246	55.1	.001	-35.3	-48.2	308.82	25	.07	452.29	101	601	.07	33
32000	246	55.6	.001	-37.6	-49.4	295.59	28	.06	437.23	98	598	.07	33
33000	250	57.4	.007	-39.9	-47.2	282.81	45	.08	422.28	95	595	.08	33
34000	256	60.1	.011	-41.9	-47.5	270.48	54	.08	407.38	91	593	.08	33
35000	262	63.3	.012	-44.5	-50.1	258.56	53	.06	393.87	88	589	.06	33
36000	266	66.2	.009	-47.1	-53.0	247.06	50	.04	380.75	85	586	.04	33
37000	270	68.1	.009	-49.9	-56.1	235.92	47	.03	368.17	82	582	.03	33
38000	274	68.3	.007	-52.7	-59.1	225.17	46	.02	355.89	79	579	.02	33
39000	277	68.7	.007	-55.5	-61.7	214.77	45	.01	343.70	77	575	.01	33
40000	280	69.1	.006	-57.8	-64.1	204.74	44	.01	331.27	74	572	.01	33
41000	280	67.7	.002	-60.3	99.9	195.08	999	99.99	319.35	71	569	.00999	
42000	272	63.6	.017	-61.9	99.9	185.78	999	99.99	306.34	68	567	.00999	
43000	260	62.9	.022	-62.8	99.9	176.88	999	99.99	293.01	65	565	.00999	
44000	254	66.1	.013	-64.1	99.9	168.36	999	99.99	280.62	63	564	.00999	
45000	253	69.4	.006	-64.3	99.9	160.22	999	99.99	267.28	60	563	.00999	
46000	254	70.5	.003	-63.3	99.9	152.50	999	99.99	253.15	56	565	.00999	
47000	252	70.3	.004	-64.7	99.9	145.14	999	99.99	242.54	54	563	.00999	
48000	253	70.8	.002	-66.6	99.9	138.08	999	99.99	232.94	52	560	.00999	
49000	258	68.2	.010	-68.2	99.9	131.31	999	99.99	223.19	50	558	.00999	
50000	257	61.7	.011	-68.4	99.9	124.84	999	99.99	212.38	47	558	.00999	
51000	250	56.7	.015	-68.6	99.9	118.69	999	99.99	202.13	45	558	.00999	
52000	999	999.0	.999	-70.0	99.9	112.82	999	99.99	193.45	43	556	.00999	

TERMINATION 52281 GEOPFT 15935 GEOPM 110.0 MBS
TROPOPAUSE 0 FEET .00 MB .0 C .0 C

MANDATORY LEVELS

GEOPFT	DIR	KTS	TEMP	DPT	PRESS	RH
705	14	15	18.2	16.0	1000.0	87
2150	57	9	17.1	16.6	950.0	97
3665	167	3	15.5	13.4	900.0	87
5253	301	7	13.6	3.0	850.0	49
6922	302	10	10.9	3.0	800.0	58
8679	306	14	7.4	-.1	750.0	59
10530	278	10	3.2	-5.8	700.0	52
12489	257	11	-.2	-19.6	650.0	22
14582	254	20	-3.1	-7.6	600.0	73
16828	245	27	-6.7	-9.9	550.0	78
19250	242	33	-11.1	-29.8	500.0	19
21887	254	34	-15.4	-34.6	450.0	17
24781	251	48	-18.8	-37.6	400.0	17
27996	247	52	-26.8	-42.8	350.0	20
31569	246	55	-36.9	-49.4	300.0	26
35628	265	66	-46.4	-52.2	250.0	51
40350	281	69	-58.9	-65.1	200.0	43
43066	258	63	-63.1	99.9	175.0	999
46166	254	70	-63.6	99.9	150.0	999
49784	257	62	-68.4	99.9	125.0	999

SIGNIFICANT LEVELS

GEOMFT	DIR	KTS	TEMP	DPT	PRESS	IR	RH
16	360	10	21.2	16.7	1024.7	352	75
198	355	20	19.1	14.7	1018.2	343	75
1078	24	14	17.9	16.7	986.9	347	92
2210	59	9	17.0	16.5	948.1	337	97
2674	76	8	16.0	15.5	932.6	329	97
3040	104	5	16.7	15.4	920.5	324	92
3223	137	4	16.7	14.0	914.5	316	84
3911	205	2	14.9	13.2	892.3	308	89
4798	286	4	14.0	7.1	864.3	279	63
4987	298	5	13.8	6.9	858.5	277	63
5365	301	7	13.5	1.5	846.8	260	44
5973	300	8	13.0	-5.5	828.4	243	27
6561	301	9	11.9	1.9	810.9	253	50
7147	303	11	10.4	3.6	793.8	254	63
7998	309	15	8.8	3.0	769.5	247	67
10189	283	11	4.0	-4.2	709.5	220	55
10764	274	10	2.8	-6.7	694.4	213	49
11912	262	10	.6	-10.5	665.0	202	43
12600	256	12	-.3	-20.9	647.9	190	19
12832	252	13	-.3	-22.1	642.2	188	17
13296	253	16	-.9	-16.6	631.0	188	29
13555	254	18	-1.4	-7.9	624.8	195	61
14072	256	19	-2.1	-15.6	612.6	185	35
14670	254	20	-3.2	-6.7	598.7	191	77
15950	247	24	-5.4	-9.9	569.9	180	71
16556	245	26	-6.3	-8.2	556.7	179	86
17266	244	28	-7.2	-12.2	541.5	171	67
17831	245	31	-8.7	-13.5	529.7	167	68
18032	247	33	-9.2	-14.1	525.5	166	68
18432	248	35	-9.7	-16.4	517.3	162	58
18636	248	35	-10.3	-17.9	513.2	160	54
19044	245	34	-10.8	-27.0	505.0	153	25
19253	242	33	-11.0	-29.7	500.8	151	20
20262	241	32	-11.6	-32.2	481.2	145	16
22007	254	34	-15.5	-34.7	448.8	137	17
23209	259	40	-18.0	-36.7	427.5	132	18
24425	254	47	-17.8	-37.3	406.9	125	16
29544	247	55	-30.8	-46.0	328.8	106	21
31462	246	55	-36.5	-49.4	302.7	100	25
32119	247	56	-37.9	-49.3	294.1	97	29
33389	252	58	-40.8	-47.0	278.0	93	51
37916	273	68	-52.5	-58.8	226.1	80	46
40502	281	69	-58.9	-65.2	199.9	72	43
43808	254	65	-63.8	99.9	170.0	63	999
45766	255	71	-63.1	99.9	154.3	57	999
48185	254	71	-66.9	99.9	136.8	51	999
51640	999	999	-69.6	99.9	114.9	44	999
52488	999	999	-70.5	99.9	110.0	42	999

TERMINATION
047 047
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Meteorological Tower Data -- 23 February 1997 2015Z

DAY	TIME	LAT	LON	Z	DIR	SPD	T	TD	TIDN
97054	201500	28.4338	80.5734	6			69		1
97054	201500	28.4338	80.5734	12	352	5.1			1
97054	201500	28.4338	80.5734	54	347	11.1	67		1
97054	201500	28.4443	80.5621	6			69	61	2
97054	201500	28.4443	80.5621	12	353	7.0			2
97054	201500	28.4443	80.5621	54	355	14.0	68	60	2
97054	201500	28.4443	80.5621	90	356	16.9			2
97054	201500	28.4443	80.5621	162	356	19.1			2
97054	201500	28.4443	80.5621	204	354	21.0	65	60	2
97054	201500	28.4443	80.5621	6					2
97054	201500	28.4443	80.5621	12	350	8.0			2
97054	201500	28.4443	80.5621	54	354	14.0	67	60	2
97054	201500	28.4443	80.5621	90	351	16.9			2
97054	201500	28.4443	80.5621	162	354	20.0			2
97054	201500	28.4443	80.5621	204	355	22.0	65	60	2
97054	201500	28.4598	80.5267	6			66		3
97054	201500	28.4598	80.5267	12	350	15.9			3
97054	201500	28.4598	80.5267	54	337	22.0			3
97054	201500	28.4466	80.5652	6					17
97054	201500	28.7435	80.7005	6			64	60	19
97054	201500	28.7435	80.7005	54	344	22.9			19
97054	201500	28.7975	80.7378	6			64	62	22
97054	201500	28.7975	80.7378	54	342	21.0			22
97054	201500	28.4721	80.5393	6					36
97054	201500	28.4721	80.5393	90	351	18.1			36
97054	201500	28.5622	80.5785	6					40
97054	201500	28.5622	80.5785	54	347	16.9			40
97054	201500	28.5836	80.5842	6					41
97054	201500	28.5836	80.5842	54	340	15.0			41
97054	201500	28.5130	80.5613	6			68	61	61
97054	201500	28.5130	80.5613	12	8	4.1			61
97054	201500	28.5130	80.5613	54	1	11.1	67	61	61
97054	201500	28.5130	80.5613	162	360	15.9			61
97054	201500	28.5130	80.5613	204	1	15.9	65	60	61
97054	201500	28.5130	80.5613	6			68	60	62
97054	201500	28.5130	80.5613	12	6	6.0			62
97054	201500	28.5130	80.5613	54	349	11.1	66	60	62
97054	201500	28.5130	80.5613	162	349	18.1			62
97054	201500	28.5130	80.5613	204	350	18.1	65	60	62
97054	201500	28.5358	80.5747	6			67		108
97054	201500	28.5358	80.5747	12	344	6.0			108
97054	201500	28.5358	80.5747	54	345	15.9	65		108
97054	201500	28.6141	80.6203	6			65		112
97054	201500	28.6141	80.6203	12	343	13.0			112
97054	201500	28.6141	80.6203	54	344	16.9	64		112
97054	201500	28.4048	80.6519	6			70	63	300
97054	201500	28.4048	80.6519	54	6	15.0			300
97054	201500	28.4600	80.5711	6			67		303
97054	201500	28.4600	80.5711	12	358	5.1			303
97054	201500	28.4600	80.5711	54	354	9.9	66		303
97054	201500	28.6027	80.6414	6			67		311
97054	201500	28.6027	80.6414	12	347	8.0			311
97054	201500	28.6027	80.6414	54	355	14.0	64		311
97054	201500	28.6105	80.6069	6					393
97054	201500	28.6105	80.6069	60	347	18.1	64	60	393
97054	201500	28.6057	80.6016	6			65	61	394
97054	201500	28.6057	80.6016	60	341	20.0	63	60	394
97054	201500	28.6294	80.6235	6					397

97054	201500	28.6294	80.6235	60	346	18.1	63	59	397
97054	201500	28.6248	80.6182	6			64	58	398
97054	201500	28.6248	80.6182	60	341	18.1	63	58	398
97054	201500	28.4586	80.5923	6			68		403
97054	201500	28.4586	80.5923	12	2	12.1			403
97054	201500	28.4586	80.5923	54	359	15.9	67		403
97054	201500	28.6062	80.6739	6			67		412
97054	201500	28.6062	80.6739	12	17	4.1			412
97054	201500	28.6062	80.6739	54	347	14.0	65		412
97054	201500	28.6586	80.6998	6			65		415
97054	201500	28.6586	80.6998	12	333	7.0			415
97054	201500	28.6586	80.6998	54	354	15.9	63		415
97054	201500	28.7055	80.7265	6			64	60	418
97054	201500	28.7055	80.7265	54	349	15.0			418
97054	201500	28.7755	80.8043	6			65	58	421
97054	201500	28.7755	80.8043	54	357	14.0			421
97054	201500	28.5158	80.6400	6			68		506
97054	201500	28.5158	80.6400	12	348	8.0			506
97054	201500	28.5158	80.6400	54	353	11.1	66		506
97054	201500	28.5623	80.6694	6			67		509
97054	201500	28.5623	80.6694	12	5	9.9			509
97054	201500	28.5623	80.6694	54	5	14.0	65		509
97054	201500	28.5986	80.6817	6					511
97054	201500	28.5986	80.6817	30	353	13.0			511
97054	201500	28.6160	80.6930	6			68	60	512
97054	201500	28.6160	80.6930	30	352	15.0			512
97054	201500	28.6307	80.7027	6					513
97054	201500	28.6307	80.7027	30	357	19.1			513
97054	201500	28.6431	80.7482	6			65		714
97054	201500	28.6431	80.7482	12	353	11.1			714
97054	201500	28.6431	80.7482	54	349	15.9	64		714
97054	201500	28.4632	80.6702	6			69		803
97054	201500	28.4632	80.6702	12	21	7.0			803
97054	201500	28.4632	80.6702	54	9	11.1	67		803
97054	201500	28.5184	80.6962	6			67		805
97054	201500	28.5184	80.6962	12	343	6.0			805
97054	201500	28.5184	80.6962	54	353	8.9	67		805
97054	201500	28.7464	80.8707	6			66	58	819
97054	201500	28.7464	80.8707	54	0	8.9			819
97054	201500	28.4079	80.7604	6			71	63	1000
97054	201500	28.4079	80.7604	54	9	11.1			1000
97054	201500	28.5272	80.7742	6			70	64	1007
97054	201500	28.5272	80.7742	54	1	15.0			1007
97054	201500	28.6056	80.8248	6			67	59	1012
97054	201500	28.6056	80.8248	54	15	9.9			1012
97054	201500	28.5697	80.5864	6			67	62	1101
97054	201500	28.5697	80.5864	12	336	4.1			1101
97054	201500	28.5697	80.5864	54	354	15.0	65	60	1101
97054	201500	28.5697	80.5864	162	351	18.1			1101
97054	201500	28.5697	80.5864	204	350	19.1	63	60	1101
97054	201500	28.5697	80.5864	6			67	61	1102
97054	201500	28.5697	80.5864	12	298	2.9			1102
97054	201500	28.5697	80.5864	54	349	15.0	65	60	1102
97054	201500	28.5697	80.5864	162	347	19.1			1102
97054	201500	28.5697	80.5864	204	344	20.0	63	59	1102
97054	201500	28.4843	80.7856	6					1204
97054	201500	28.4843	80.7856	54	9	11.1			1204
97054	201500	28.6445	80.9034	6					1215
97054	201500	28.4114	80.9284	6			73	72	1500
97054	201500	28.4114	80.9284	54	29	4.1			1500
97054	201500	28.4475	80.8538	6					1502

97054	201500	28.4960	80.8843	6					1605
97054	201500	28.4960	80.8843	54					1605
97054	201500	28.5583	80.9132	6					1609
97054	201500	28.6173	80.9581	6			69	61	1612
97054	201500	28.6173	80.9581	54	0	8.9			1612
97054	201500	28.6762	80.9987	6					1617
97054	201500	28.6762	80.9987	54					1617
97054	201500	28.5231	81.0100	6			70	61	2008
97054	201500	28.5231	81.0100	54	14	11.1			2008
97054	201500	28.6489	81.0693	6			68	58	2016
97054	201500	28.6489	81.0693	54	18	11.1			2016
97054	201500	28.4417	81.0291	6					2202
97054	201500	28.4417	81.0291	54					2202
97054	201500	28.6256	80.6571	6			66	60	3131
97054	201500	28.6256	80.6571	12	340	12.1			3131
97054	201500	28.6256	80.6571	54	344	18.1	64	60	3131
97054	201500	28.6256	80.6571	162	342	22.9			3131
97054	201500	28.6256	80.6571	204	341	23.9	63	60	3131
97054	201500	28.6256	80.6571	295	344	25.1			3131
97054	201500	28.6256	80.6571	394	341	25.1			3131
97054	201500	28.6256	80.6571	492	337	25.1	61	59	3131
97054	201500	28.6256	80.6571	6			66	59	3132
97054	201500	28.6256	80.6571	12	339	13.0			3132
97054	201500	28.6256	80.6571	54	347	19.1	64	59	3132
97054	201500	28.6256	80.6571	162	348	23.9			3132
97054	201500	28.6256	80.6571	204	352	25.1	63	59	3132
97054	201500	28.6256	80.6571	295	348	25.1			3132
97054	201500	28.6256	80.6571	394	351	26.0			3132
97054	201500	28.6256	80.6571	492	351	26.0	61	59	3132
97054	201500	28.3932	80.8211	6			71	61	9001
97054	201500	28.3932	80.8211	54	8	8.9			9001
97054	201500	28.3382	80.7321	6			73	64	9404
97054	201500	28.3382	80.7321	54	355	8.9			9404

Meteorological Tower Data -- 23 February 1997 2020Z

DAY	TIME	LAT	LON	Z	DIR	SPD	T	TD	TIDN
97054	202000	28.4338	80.5734	6			69		1
97054	202000	28.4338	80.5734	12	353	5.1			1
97054	202000	28.4338	80.5734	54	346	9.9	67		1
97054	202000	28.4443	80.5621	6			69	61	2
97054	202000	28.4443	80.5621	12	351	7.0			2
97054	202000	28.4443	80.5621	54	355	12.1	67	60	2
97054	202000	28.4443	80.5621	90	357	15.0			2
97054	202000	28.4443	80.5621	162	356	18.1			2
97054	202000	28.4443	80.5621	204	355	18.1	65	61	2
97054	202000	28.4443	80.5621	6					2
97054	202000	28.4443	80.5621	12	349	6.0			2
97054	202000	28.4443	80.5621	54	352	12.1	67	60	2
97054	202000	28.4443	80.5621	90	351	15.0			2
97054	202000	28.4443	80.5621	162	354	18.1			2
97054	202000	28.4443	80.5621	204	356	18.1	65	60	2
97054	202000	28.4598	80.5267	6			66		3
97054	202000	28.4598	80.5267	12	351	15.9			3
97054	202000	28.4598	80.5267	54	338	22.0			3
97054	202000	28.4466	80.5652	6					17
97054	202000	28.7435	80.7005	6			64	60	19
97054	202000	28.7435	80.7005	54	344	23.9			19
97054	202000	28.7975	80.7378	6			64	62	22
97054	202000	28.7975	80.7378	54	341	22.0			22
97054	202000	28.4721	80.5393	6					36
97054	202000	28.4721	80.5393	90	355	15.9			36
97054	202000	28.5622	80.5785	6					40
97054	202000	28.5622	80.5785	54	354	14.0			40
97054	202000	28.5836	80.5842	6					41
97054	202000	28.5836	80.5842	54	340	12.1			41
97054	202000	28.5130	80.5613	6			69	62	61
97054	202000	28.5130	80.5613	12	1	2.9			61
97054	202000	28.5130	80.5613	54	4	9.9	67	62	61
97054	202000	28.5130	80.5613	162	3	15.9			61
97054	202000	28.5130	80.5613	204	2	16.9	65	61	61
97054	202000	28.5130	80.5613	6			68	61	62
97054	202000	28.5130	80.5613	12	1	4.1			62
97054	202000	28.5130	80.5613	54	353	9.9	66	61	62
97054	202000	28.5130	80.5613	162	354	16.9			62
97054	202000	28.5130	80.5613	204	355	18.1	65	60	62
97054	202000	28.5358	80.5747	6			67		108
97054	202000	28.5358	80.5747	12	346	7.0			108
97054	202000	28.5358	80.5747	54	343	15.9	65		108
97054	202000	28.6141	80.6203	6			66		112
97054	202000	28.6141	80.6203	12	347	9.9			112
97054	202000	28.6141	80.6203	54	347	15.0	65		112
97054	202000	28.4048	80.6519	6			69	63	300
97054	202000	28.4048	80.6519	54	6	15.9			300
97054	202000	28.4600	80.5711	6			67		303
97054	202000	28.4600	80.5711	12	356	6.0			303
97054	202000	28.4600	80.5711	54	350	12.1	66		303
97054	202000	28.6027	80.6414	6			66		311
97054	202000	28.6027	80.6414	12	349	8.0			311
97054	202000	28.6027	80.6414	54	353	15.0	64		311
97054	202000	28.6105	80.6069	6					393
97054	202000	28.6105	80.6069	60	345	19.1	64	60	393
97054	202000	28.6057	80.6016	6			65	61	394
97054	202000	28.6057	80.6016	60	340	19.1	63	61	394
97054	202000	28.6294	80.6235	6					397
97054	202000	28.6294	80.6235	60	348	20.0	63	59	397
97054	202000	28.6248	80.6182	6			64	58	398
97054	202000	28.6248	80.6182	60	339	18.1	63	58	398

97054	202000	28.4586	80.5923	6			67		403
97054	202000	28.4586	80.5923	12	2	12.1			403
97054	202000	28.4586	80.5923	54	360	15.9	67		403
97054	202000	28.6062	80.6739	6			66		412
97054	202000	28.6062	80.6739	12	8	4.1			412
97054	202000	28.6062	80.6739	54	350	15.9	65		412
97054	202000	28.6586	80.6998	6			65		415
97054	202000	28.6586	80.6998	12	320	8.0			415
97054	202000	28.6586	80.6998	54	346	16.9	63		415
97054	202000	28.7055	80.7265	6			65	60	418
97054	202000	28.7055	80.7265	54	348	14.0			418
97054	202000	28.7755	80.8043	6			64	58	421
97054	202000	28.7755	80.8043	54	352	15.0			421
97054	202000	28.5158	80.6400	6			67		506
97054	202000	28.5158	80.6400	12	346	9.9			506
97054	202000	28.5158	80.6400	54	350	13.0	66		506
97054	202000	28.5623	80.6694	6			66		509
97054	202000	28.5623	80.6694	12	1	11.1			509
97054	202000	28.5623	80.6694	54	360	15.0	65		509
97054	202000	28.5986	80.6817	6					511
97054	202000	28.5986	80.6817	30	358	15.0			511
97054	202000	28.6160	80.6930	6			67	60	512
97054	202000	28.6160	80.6930	30	349	15.9			512
97054	202000	28.6307	80.7027	6					513
97054	202000	28.6307	80.7027	30	352	15.9			513
97054	202000	28.6431	80.7482	6			65		714
97054	202000	28.6431	80.7482	12	357	11.1			714
97054	202000	28.6431	80.7482	54	352	18.1	63		714
97054	202000	28.4632	80.6702	6			69		803
97054	202000	28.4632	80.6702	12	19	6.0			803
97054	202000	28.4632	80.6702	54	9	8.9	67		803
97054	202000	28.5184	80.6962	6			67		805
97054	202000	28.5184	80.6962	12	352	6.0			805
97054	202000	28.5184	80.6962	54	5	8.0	66		805
97054	202000	28.7464	80.8707	6			66	58	819
97054	202000	28.7464	80.8707	54	357	8.9			819
97054	202000	28.4079	80.7604	6			71	63	1000
97054	202000	28.4079	80.7604	54	13	11.1			1000
97054	202000	28.5272	80.7742	6			70	64	1007
97054	202000	28.5272	80.7742	54	3	16.9			1007
97054	202000	28.6056	80.8248	6			67	59	1012
97054	202000	28.6056	80.8248	54	12	9.9			1012
97054	202000	28.5697	80.5864	6			67	62	1101
97054	202000	28.5697	80.5864	12	333	6.0			1101
97054	202000	28.5697	80.5864	54	349	15.0	65	61	1101
97054	202000	28.5697	80.5864	162	348	19.1			1101
97054	202000	28.5697	80.5864	204	349	19.1	63	60	1101
97054	202000	28.5697	80.5864	6			67	62	1102
97054	202000	28.5697	80.5864	12	289	4.1			1102
97054	202000	28.5697	80.5864	54	343	15.0	65	60	1102
97054	202000	28.5697	80.5864	162	344	19.1			1102
97054	202000	28.5697	80.5864	204	343	20.0	63	60	1102
97054	202000	28.4843	80.7856	6					1204
97054	202000	28.4843	80.7856	54	11	12.1			1204
97054	202000	28.6445	80.9034	6					1215
97054	202000	28.4114	80.9284	6			73	72	1500
97054	202000	28.4114	80.9284	54	18	2.9			1500
97054	202000	28.4475	80.8538	6					1502
97054	202000	28.4960	80.8843	6					1605
97054	202000	28.4960	80.8843	54					1605
97054	202000	28.5583	80.9132	6					1609
97054	202000	28.6173	80.9581	6			69	61	1612
97054	202000	28.6173	80.9581	54	357	8.0			1612
97054	202000	28.6762	80.9987	6			68	58	1617
97054	202000	28.6762	80.9987	54	8	8.9			1617

97054	202000	28.5231	81.0100	6			70	60	2008
97054	202000	28.5231	81.0100	54	15	11.1			2008
97054	202000	28.6489	81.0693	6			68	59	2016
97054	202000	28.6489	81.0693	54	20	11.1			2016
97054	202000	28.4417	81.0291	6					2202
97054	202000	28.4417	81.0291	54					2202
97054	202000	28.6256	80.6571	6			66	60	3131
97054	202000	28.6256	80.6571	12	340	12.1			3131
97054	202000	28.6256	80.6571	54	344	19.1	64	60	3131
97054	202000	28.6256	80.6571	162	341	22.9			3131
97054	202000	28.6256	80.6571	204	341	23.9	63	60	3131
97054	202000	28.6256	80.6571	295	344	25.1			3131
97054	202000	28.6256	80.6571	394	341	25.1			3131
97054	202000	28.6256	80.6571	492	337	25.1	61	59	3131
97054	202000	28.6256	80.6571	6			65	59	3132
97054	202000	28.6256	80.6571	12	339	13.0			3132
97054	202000	28.6256	80.6571	54	347	19.1	64	59	3132
97054	202000	28.6256	80.6571	162	347	23.9			3132
97054	202000	28.6256	80.6571	204	352	23.9	63	59	3132
97054	202000	28.6256	80.6571	295	348	26.0			3132
97054	202000	28.6256	80.6571	394	350	26.0			3132
97054	202000	28.6256	80.6571	492	351	26.0	61	58	3132
97054	202000	28.3932	80.8211	6			70	61	9001
97054	202000	28.3932	80.8211	54	2	8.9			9001
97054	202000	28.3382	80.7321	6			72	63	9404
97054	202000	28.3382	80.7321	54	354	9.9			9404

Meteorological Tower Data -- 23 February 1997 2025Z

DAY	TIME	LAT	LON	Z	DIR	SPD	T	TD	TIDN
97054	202500	28.4338	80.5734	6			68		1
97054	202500	28.4338	80.5734	12	354	5.1			1
97054	202500	28.4338	80.5734	54	352	9.9	67		1
97054	202500	28.4443	80.5621	6			68	61	2
97054	202500	28.4443	80.5621	12	350	7.0			2
97054	202500	28.4443	80.5621	54	355	14.0	67	60	2
97054	202500	28.4443	80.5621	90	355	18.1			2
97054	202500	28.4443	80.5621	162	355	21.0			2
97054	202500	28.4443	80.5621	204	354	21.0	65	61	2
97054	202500	28.4443	80.5621	6					2
97054	202500	28.4443	80.5621	12	348	8.0			2
97054	202500	28.4443	80.5621	54	353	15.0	67	60	2
97054	202500	28.4443	80.5621	90	351	19.1			2
97054	202500	28.4443	80.5621	162	353	21.0			2
97054	202500	28.4443	80.5621	204	354	22.0	65	60	2
97054	202500	28.4598	80.5267	6			66		3
97054	202500	28.4598	80.5267	12	350	15.0			3
97054	202500	28.4598	80.5267	54	338	21.0			3
97054	202500	28.4466	80.5652	6					17
97054	202500	28.7435	80.7005	6			64	60	19
97054	202500	28.7435	80.7005	54	341	23.9			19
97054	202500	28.7975	80.7378	6			63	61	22
97054	202500	28.7975	80.7378	54	343	22.0			22
97054	202500	28.4721	80.5393	6					36
97054	202500	28.4721	80.5393	90	357	15.0			36
97054	202500	28.5622	80.5785	6					40
97054	202500	28.5622	80.5785	54	348	15.9			40
97054	202500	28.5836	80.5842	6					41
97054	202500	28.5836	80.5842	54	339	14.0			41
97054	202500	28.5130	80.5613	6			69	62	61
97054	202500	28.5130	80.5613	12	345	4.1			61
97054	202500	28.5130	80.5613	54	356	9.9	67	62	61
97054	202500	28.5130	80.5613	162	358	15.0			61
97054	202500	28.5130	80.5613	204	355	15.0	65	61	61
97054	202500	28.5130	80.5613	6			69	61	62
97054	202500	28.5130	80.5613	12	355	4.1			62
97054	202500	28.5130	80.5613	54	346	9.9	67	61	62
97054	202500	28.5130	80.5613	162	348	16.9			62
97054	202500	28.5130	80.5613	204	348	18.1	65	60	62
97054	202500	28.5358	80.5747	6			67		108
97054	202500	28.5358	80.5747	12	348	6.0			108
97054	202500	28.5358	80.5747	54	345	15.0	65		108
97054	202500	28.6141	80.6203	6			65		112
97054	202500	28.6141	80.6203	12	347	12.1			112
97054	202500	28.6141	80.6203	54	343	19.1	64		112
97054	202500	28.4048	80.6519	6			69	63	300
97054	202500	28.4048	80.6519	54	7	16.9			300
97054	202500	28.4600	80.5711	6			67		303
97054	202500	28.4600	80.5711	12	347	7.0			303
97054	202500	28.4600	80.5711	54	342	13.0	66		303
97054	202500	28.6027	80.6414	6			66		311
97054	202500	28.6027	80.6414	12	348	8.9			311
97054	202500	28.6027	80.6414	54	354	15.9	64		311
97054	202500	28.6105	80.6069	6					393
97054	202500	28.6105	80.6069	60	346	20.0	64	60	393
97054	202500	28.6057	80.6016	6			65	61	394
97054	202500	28.6057	80.6016	60	341	20.0	63	60	394
97054	202500	28.6294	80.6235	6					397
97054	202500	28.6294	80.6235	60	347	16.9	63	60	397
97054	202500	28.6248	80.6182	6			64	58	398
97054	202500	28.6248	80.6182	60	343	16.9	64	59	398

97054	202500	28.4586	80.5923	6			67		403
97054	202500	28.4586	80.5923	12	360	12.1			403
97054	202500	28.4586	80.5923	54	358	15.9	66		403
97054	202500	28.6062	80.6739	6			66		412
97054	202500	28.6062	80.6739	12	13	5.1			412
97054	202500	28.6062	80.6739	54	352	15.9	65		412
97054	202500	28.6586	80.6998	6			65		415
97054	202500	28.6586	80.6998	12	320	7.0			415
97054	202500	28.6586	80.6998	54	348	13.0	64		415
97054	202500	28.7055	80.7265	6			65	60	418
97054	202500	28.7055	80.7265	54	351	15.9			418
97054	202500	28.7755	80.8043	6			64	57	421
97054	202500	28.7755	80.8043	54	353	15.0			421
97054	202500	28.5158	80.6400	6			67		506
97054	202500	28.5158	80.6400	12	346	11.1			506
97054	202500	28.5158	80.6400	54	350	14.0	66		506
97054	202500	28.5623	80.6694	6			66		509
97054	202500	28.5623	80.6694	12	357	9.9			509
97054	202500	28.5623	80.6694	54	357	14.0	65		509
97054	202500	28.5986	80.6817	6					511
97054	202500	28.5986	80.6817	30	2	13.0			511
97054	202500	28.6160	80.6930	6			68	60	512
97054	202500	28.6160	80.6930	30	348	16.9			512
97054	202500	28.6307	80.7027	6					513
97054	202500	28.6307	80.7027	30	349	16.9			513
97054	202500	28.6431	80.7482	6			65		714
97054	202500	28.6431	80.7482	12	353	9.9			714
97054	202500	28.6431	80.7482	54	350	15.9	64		714
97054	202500	28.4632	80.6702	6			69		803
97054	202500	28.4632	80.6702	12	8	6.0			803
97054	202500	28.4632	80.6702	54	1	11.1	67		803
97054	202500	28.5184	80.6962	6			67		805
97054	202500	28.5184	80.6962	12	6	5.1			805
97054	202500	28.5184	80.6962	54	10	8.9	66		805
97054	202500	28.7464	80.8707	6			66	58	819
97054	202500	28.7464	80.8707	54	5	8.9			819
97054	202500	28.4079	80.7604	6			71	63	1000
97054	202500	28.4079	80.7604	54	18	12.1			1000
97054	202500	28.5272	80.7742	6			70	64	1007
97054	202500	28.5272	80.7742	54	2	16.9			1007
97054	202500	28.6056	80.8248	6			67	60	1012
97054	202500	28.6056	80.8248	54	13	8.9			1012
97054	202500	28.5697	80.5864	6			67	62	1101
97054	202500	28.5697	80.5864	12	333	5.1			1101
97054	202500	28.5697	80.5864	54	352	16.9	65	60	1101
97054	202500	28.5697	80.5864	162	347	20.0			1101
97054	202500	28.5697	80.5864	204	348	20.0	63	60	1101
97054	202500	28.5697	80.5864	6			67	61	1102
97054	202500	28.5697	80.5864	12	292	4.1			1102
97054	202500	28.5697	80.5864	54	346	16.9	65	60	1102
97054	202500	28.5697	80.5864	162	344	21.0			1102
97054	202500	28.5697	80.5864	204	342	21.0	63	59	1102
97054	202500	28.4843	80.7856	6					1204
97054	202500	28.4843	80.7856	54	6	12.1			1204
97054	202500	28.6445	80.9034	6					1215
97054	202500	28.4114	80.9284	6			72	72	1500
97054	202500	28.4114	80.9284	54	34	2.9			1500
97054	202500	28.4475	80.8538	6					1502
97054	202500	28.4960	80.8843	6					1605
97054	202500	28.4960	80.8843	54					1605
97054	202500	28.5583	80.9132	6					1609
97054	202500	28.6173	80.9581	6			69	60	1612
97054	202500	28.6173	80.9581	54	357	8.9			1612
97054	202500	28.6762	80.9987	6			67	58	1617

97054	202500	28.6762	80.9987	54	358	8.9			1617
97054	202500	28.5231	81.0100	6			70	61	2008
97054	202500	28.5231	81.0100	54	16	8.0			2008
97054	202500	28.6489	81.0693	6			68	59	2016
97054	202500	28.6489	81.0693	54	7	11.1			2016
97054	202500	28.4417	81.0291	6					2202
97054	202500	28.4417	81.0291	54					2202
97054	202500	28.6256	80.6571	6			65	60	3131
97054	202500	28.6256	80.6571	12	345	12.1			3131
97054	202500	28.6256	80.6571	54	346	19.1	64	60	3131
97054	202500	28.6256	80.6571	162	342	22.0			3131
97054	202500	28.6256	80.6571	204	341	22.9	63	60	3131
97054	202500	28.6256	80.6571	295	344	22.9			3131
97054	202500	28.6256	80.6571	394	340	23.9			3131
97054	202500	28.6256	80.6571	492	336	23.9	61	59	3131
97054	202500	28.6256	80.6571	6			65	59	3132
97054	202500	28.6256	80.6571	12	343	12.1			3132
97054	202500	28.6256	80.6571	54	351	19.1	64	59	3132
97054	202500	28.6256	80.6571	162	348	22.9			3132
97054	202500	28.6256	80.6571	204	353	23.9	62	59	3132
97054	202500	28.6256	80.6571	295	348	22.9			3132
97054	202500	28.6256	80.6571	394	351	23.9			3132
97054	202500	28.6256	80.6571	492	350	25.1	61	59	3132
97054	202500	28.3932	80.8211	6			70	61	9001
97054	202500	28.3932	80.8211	54	11	9.9			9001
97054	202500	28.3382	80.7321	6			71	63	9404
97054	202500	28.3382	80.7321	54	351	8.9			9404

Meteorological Tower Data -- 23 February 1997 2030Z

DAY	TIME	LAT	LON	Z	DIR	SPD	T	TD	TIDN
97054	203000	28.4338	80.5734	6			68		1
97054	203000	28.4338	80.5734	12	353	5.1			1
97054	203000	28.4338	80.5734	54	352	9.9	67		1
97054	203000	28.4443	80.5621	6			68	61	2
97054	203000	28.4443	80.5621	12	346	6.0			2
97054	203000	28.4443	80.5621	54	352	12.1	67	60	2
97054	203000	28.4443	80.5621	90	355	15.0			2
97054	203000	28.4443	80.5621	162	355	18.1			2
97054	203000	28.4443	80.5621	204	354	19.1	65	61	2
97054	203000	28.4443	80.5621	6					2
97054	203000	28.4443	80.5621	12	348	7.0			2
97054	203000	28.4443	80.5621	54	348	12.1	67	60	2
97054	203000	28.4443	80.5621	162	353	18.1			2
97054	203000	28.4443	80.5621	204	355	20.0	65	60	2
97054	203000	28.4598	80.5267	6			66		3
97054	203000	28.4598	80.5267	12	349	15.0			3
97054	203000	28.4598	80.5267	54	337	21.0			3
97054	203000	28.4466	80.5652	6					17
97054	203000	28.7435	80.7005	6			64	60	19
97054	203000	28.7435	80.7005	54	342	22.9			19
97054	203000	28.7975	80.7378	6			63	61	22
97054	203000	28.7975	80.7378	54	342	22.9			22
97054	203000	28.4721	80.5393	6					36
97054	203000	28.4721	80.5393	90	352	15.0			36
97054	203000	28.5622	80.5785	6					40
97054	203000	28.5622	80.5785	54	352	15.0			40
97054	203000	28.5836	80.5842	6					41
97054	203000	28.5836	80.5842	54	339	14.0			41
97054	203000	28.5130	80.5613	6			68	61	61
97054	203000	28.5130	80.5613	12	343	5.1			61
97054	203000	28.5130	80.5613	54	349	9.9	67	62	61
97054	203000	28.5130	80.5613	162	352	16.9			61
97054	203000	28.5130	80.5613	204	353	15.9	65	61	61
97054	203000	28.5130	80.5613	6			68	61	62
97054	203000	28.5130	80.5613	12	339	5.1			62
97054	203000	28.5130	80.5613	54	338	11.1	66	61	62
97054	203000	28.5130	80.5613	162	343	19.1			62
97054	203000	28.5130	80.5613	204	345	20.0	65	60	62
97054	203000	28.5358	80.5747	6			66		108
97054	203000	28.5358	80.5747	12	343	5.1			108
97054	203000	28.5358	80.5747	54	342	13.0	65		108
97054	203000	28.6141	80.6203	6			65		112
97054	203000	28.6141	80.6203	12	345	13.0			112
97054	203000	28.6141	80.6203	54	344	18.1	64		112
97054	203000	28.4048	80.6519	6			69	63	300
97054	203000	28.4048	80.6519	54	5	16.9			300
97054	203000	28.4600	80.5711	6			67		303
97054	203000	28.4600	80.5711	12	350	6.0			303
97054	203000	28.4600	80.5711	54	346	12.1	66		303
97054	203000	28.6027	80.6414	6			66		311
97054	203000	28.6027	80.6414	12	344	9.9			311
97054	203000	28.6027	80.6414	54	351	16.9	64		311
97054	203000	28.6105	80.6069	6					393
97054	203000	28.6105	80.6069	60	345	19.1	64	60	393
97054	203000	28.6057	80.6016	6			65	61	394
97054	203000	28.6057	80.6016	60	341	21.0	63	60	394
97054	203000	28.6294	80.6235	6					397
97054	203000	28.6294	80.6235	60	348	19.1	63	60	397
97054	203000	28.6248	80.6182	6			64	58	398
97054	203000	28.6248	80.6182	60	343	20.0	63	58	398

97054	203000	28.4586	80.5923	6			66		403
97054	203000	28.4586	80.5923	12	359	14.0			403
97054	203000	28.4586	80.5923	54	356	18.1	66		403
97054	203000	28.6062	80.6739	6			66		412
97054	203000	28.6062	80.6739	12	8	4.1			412
97054	203000	28.6062	80.6739	54	346	15.0	65		412
97054	203000	28.6586	80.6998	6			65		415
97054	203000	28.6586	80.6998	12	327	7.0			415
97054	203000	28.6586	80.6998	54	352	14.0	64		415
97054	203000	28.7055	80.7265	6			64	60	418
97054	203000	28.7055	80.7265	54	352	15.0			418
97054	203000	28.7755	80.8043	6			64	57	421
97054	203000	28.7755	80.8043	54	350	15.9			421
97054	203000	28.5158	80.6400	6			67		506
97054	203000	28.5158	80.6400	12	352	9.9			506
97054	203000	28.5158	80.6400	54	356	13.0	65		506
97054	203000	28.5623	80.6694	6			66		509
97054	203000	28.5623	80.6694	12	356	8.0			509
97054	203000	28.5623	80.6694	54	358	11.1	65		509
97054	203000	28.5986	80.6817	6					511
97054	203000	28.5986	80.6817	30	349	13.0			511
97054	203000	28.6160	80.6930	6			68	60	512
97054	203000	28.6160	80.6930	30	346	15.0			512
97054	203000	28.6307	80.7027	6					513
97054	203000	28.6307	80.7027	30	351	19.1			513
97054	203000	28.6431	80.7482	6			65		714
97054	203000	28.6431	80.7482	12	349	11.1			714
97054	203000	28.6431	80.7482	54	349	15.0	64		714
97054	203000	28.4632	80.6702	6			68		803
97054	203000	28.4632	80.6702	12	6	6.0			803
97054	203000	28.4632	80.6702	54	354	11.1	67		803
97054	203000	28.5184	80.6962	6			66		805
97054	203000	28.5184	80.6962	12	354	5.1			805
97054	203000	28.5184	80.6962	54	0	8.9	65		805
97054	203000	28.7464	80.8707	6			65	58	819
97054	203000	28.7464	80.8707	54	4	8.0			819
97054	203000	28.4079	80.7604	6			70	63	1000
97054	203000	28.4079	80.7604	54	17	15.0			1000
97054	203000	28.5272	80.7742	6			69	63	1007
97054	203000	28.5272	80.7742	54	3	15.9			1007
97054	203000	28.6056	80.8248	6			67	59	1012
97054	203000	28.6056	80.8248	54	4	9.9			1012
97054	203000	28.5697	80.5864	6			67	62	1101
97054	203000	28.5697	80.5864	12	331	6.0			1101
97054	203000	28.5697	80.5864	54	350	15.0	65	61	1101
97054	203000	28.5697	80.5864	162	348	18.1			1101
97054	203000	28.5697	80.5864	204	349	18.1	63	60	1101
97054	203000	28.5697	80.5864	6			67	61	1102
97054	203000	28.5697	80.5864	12	288	5.1			1102
97054	203000	28.5697	80.5864	54	344	15.0	65	60	1102
97054	203000	28.5697	80.5864	162	344	19.1			1102
97054	203000	28.5697	80.5864	204	343	19.1	63	60	1102
97054	203000	28.4843	80.7856	6					1204
97054	203000	28.4843	80.7856	54	6	13.0			1204
97054	203000	28.6445	80.9034	6					1215
97054	203000	28.4114	80.9284	6			72	72	1500
97054	203000	28.4114	80.9284	54	7	4.1			1500
97054	203000	28.4475	80.8538	6					1502
97054	203000	28.4960	80.8843	6					1605
97054	203000	28.4960	80.8843	54					1605
97054	203000	28.5583	80.9132	6					1609
97054	203000	28.6173	80.9581	6			69	60	1612

97054	203000	28.6173	80.9581	54	359	11.1			1612
97054	203000	28.6762	80.9987	6					1617
97054	203000	28.6762	80.9987	54					1617
97054	203000	28.5231	81.0100	6			70	61	2008
97054	203000	28.5231	81.0100	54	13	8.9			2008
97054	203000	28.6489	81.0693	6			68	58	2016
97054	203000	28.6489	81.0693	54	3	14.0			2016
97054	203000	28.4417	81.0291	6					2202
97054	203000	28.4417	81.0291	54					2202
97054	203000	28.6256	80.6571	6			66	60	3131
97054	203000	28.6256	80.6571	12	339	12.1			3131
97054	203000	28.6256	80.6571	54	344	21.0	64	60	3131
97054	203000	28.6256	80.6571	162	342	23.9			3131
97054	203000	28.6256	80.6571	204	342	23.9	63	60	3131
97054	203000	28.6256	80.6571	295	346	23.9			3131
97054	203000	28.6256	80.6571	394	343	25.1			3131
97054	203000	28.6256	80.6571	492	339	25.1	61	59	3131
97054	203000	28.6256	80.6571	6			65	59	3132
97054	203000	28.6256	80.6571	12	337	13.0			3132
97054	203000	28.6256	80.6571	54	347	22.0	64	59	3132
97054	203000	28.6256	80.6571	162	348	25.1			3132
97054	203000	28.6256	80.6571	204	353	25.1	63	59	3132
97054	203000	28.6256	80.6571	295	350	25.1			3132
97054	203000	28.6256	80.6571	394	353	25.1			3132
97054	203000	28.6256	80.6571	492	353	25.1	61	58	3132
97054	203000	28.3932	80.8211	6			70	61	9001
97054	203000	28.3932	80.8211	54	6	9.9			9001
97054	203000	28.3382	80.7321	6			71	63	9404
97054	203000	28.3382	80.7321	54	358	9.9			9404

Meteorological Tower Data -- 23 February 1997 2035Z

DAY	TIME	LAT	LON	Z	DIR	SPD	T	TD	TIDN
97054	203500	28.4338	80.5734	6			69		1
97054	203500	28.4338	80.5734	12	348	6.0			1
97054	203500	28.4338	80.5734	54	345	11.1	67		1
97054	203500	28.4443	80.5621	6			69	61	2
97054	203500	28.4443	80.5621	12	354	8.0			2
97054	203500	28.4443	80.5621	54	357	13.0	67	60	2
97054	203500	28.4443	80.5621	90	356	15.0			2
97054	203500	28.4443	80.5621	162	357	18.1			2
97054	203500	28.4443	80.5621	204	354	19.1	65	61	2
97054	203500	28.4443	80.5621	6					2
97054	203500	28.4443	80.5621	12	353	8.0			2
97054	203500	28.4443	80.5621	54	354	13.0	67	60	2
97054	203500	28.4443	80.5621	90	353	15.9			2
97054	203500	28.4443	80.5621	162	355	18.1			2
97054	203500	28.4443	80.5621	204	354	19.1	65	60	2
97054	203500	28.4598	80.5267	6			66		3
97054	203500	28.4598	80.5267	12	348	15.9			3
97054	203500	28.4598	80.5267	54	335	22.0			3
97054	203500	28.4466	80.5652	6					17
97054	203500	28.7435	80.7005	6			64	60	19
97054	203500	28.7435	80.7005	54	342	22.9			19
97054	203500	28.7975	80.7378	6			63	61	22
97054	203500	28.7975	80.7378	54	340	22.9			22
97054	203500	28.4721	80.5393	6					36
97054	203500	28.4721	80.5393	90	350	15.0			36
97054	203500	28.5622	80.5785	6					40
97054	203500	28.5622	80.5785	54	353	15.0			40
97054	203500	28.5836	80.5842	6					41
97054	203500	28.5836	80.5842	54	337	14.0			41
97054	203500	28.5130	80.5613	6			68	62	61
97054	203500	28.5130	80.5613	12	351	2.9			61
97054	203500	28.5130	80.5613	54	353	8.9	67	62	61
97054	203500	28.5130	80.5613	162	351	13.0			61
97054	203500	28.5130	80.5613	204	351	13.0	65	61	61
97054	203500	28.5130	80.5613	6			68	61	62
97054	203500	28.5130	80.5613	12	354	4.1			62
97054	203500	28.5130	80.5613	54	345	9.9	66	61	62
97054	203500	28.5130	80.5613	162	345	15.0			62
97054	203500	28.5130	80.5613	204	346	15.9	65	60	62
97054	203500	28.5358	80.5747	6			66		108
97054	203500	28.5358	80.5747	12	345	7.0			108
97054	203500	28.5358	80.5747	54	343	16.9	64		108
97054	203500	28.6141	80.6203	6			65		112
97054	203500	28.6141	80.6203	12	348	12.1			112
97054	203500	28.6141	80.6203	54	344	16.9	64		112
97054	203500	28.4048	80.6519	6			69	63	300
97054	203500	28.4048	80.6519	54	7	19.1			300
97054	203500	28.4600	80.5711	6			67		303
97054	203500	28.4600	80.5711	12	357	6.0			303
97054	203500	28.4600	80.5711	54	349	12.1	66		303
97054	203500	28.6027	80.6414	6			65		311
97054	203500	28.6027	80.6414	12	348	9.9			311
97054	203500	28.6027	80.6414	54	356	18.1	63		311
97054	203500	28.6105	80.6069	6					393
97054	203500	28.6105	80.6069	60	345	21.0	64	60	393
97054	203500	28.6057	80.6016	6			65	61	394
97054	203500	28.6057	80.6016	60	342	20.0	64	61	394
97054	203500	28.6294	80.6235	6					397
97054	203500	28.6294	80.6235	60	348	21.0	63	59	397

97054	203500	28.6248	80.6182	6			64	58	398
97054	203500	28.6248	80.6182	60	342	16.9	63	59	398
97054	203500	28.4586	80.5923	6			68		403
97054	203500	28.4586	80.5923	12	2	11.1			403
97054	203500	28.4586	80.5923	54	359	13.0	67		403
97054	203500	28.6062	80.6739	6			65		412
97054	203500	28.6062	80.6739	12	10	4.1			412
97054	203500	28.6062	80.6739	54	351	16.9	64		412
97054	203500	28.6586	80.6998	6			64		415
97054	203500	28.6586	80.6998	12	331	8.0			415
97054	203500	28.6586	80.6998	54	352	18.1	63		415
97054	203500	28.7055	80.7265	6			64	60	418
97054	203500	28.7055	80.7265	54	348	15.0			418
97054	203500	28.7755	80.8043	6			63	57	421
97054	203500	28.7755	80.8043	54	352	14.0			421
97054	203500	28.5158	80.6400	6			67		506
97054	203500	28.5158	80.6400	12	349	9.9			506
97054	203500	28.5158	80.6400	54	355	13.0	66		506
97054	203500	28.5623	80.6694	6			66		509
97054	203500	28.5623	80.6694	12	355	11.1			509
97054	203500	28.5623	80.6694	54	356	15.0	65		509
97054	203500	28.5986	80.6817	6					511
97054	203500	28.5986	80.6817	30	358	14.0			511
97054	203500	28.6160	80.6930	6			68	60	512
97054	203500	28.6160	80.6930	30	346	15.0			512
97054	203500	28.6307	80.7027	6					513
97054	203500	28.6307	80.7027	30	352	15.0			513
97054	203500	28.6431	80.7482	6			65		714
97054	203500	28.6431	80.7482	12	356	8.9			714
97054	203500	28.6431	80.7482	54	351	14.0	64		714
97054	203500	28.4632	80.6702	6			68		803
97054	203500	28.4632	80.6702	12	10	6.0			803
97054	203500	28.4632	80.6702	54	356	9.9	66		803
97054	203500	28.5184	80.6962	6			66		805
97054	203500	28.5184	80.6962	12	350	6.0			805
97054	203500	28.5184	80.6962	54	356	9.9	65		805
97054	203500	28.7464	80.8707	6			65	58	819
97054	203500	28.7464	80.8707	54	5	8.9			819
97054	203500	28.4079	80.7604	6			70	63	1000
97054	203500	28.4079	80.7604	54	14	12.1			1000
97054	203500	28.5272	80.7742	6			69	63	1007
97054	203500	28.5272	80.7742	54	2	15.9			1007
97054	203500	28.6056	80.8248	6			66	59	1012
97054	203500	28.6056	80.8248	54	10	9.9			1012
97054	203500	28.5697	80.5864	6			66	62	1101
97054	203500	28.5697	80.5864	12	333	5.1			1101
97054	203500	28.5697	80.5864	54	351	18.1	65	60	1101
97054	203500	28.5697	80.5864	162	350	21.0			1101
97054	203500	28.5697	80.5864	204	349	22.0	63	60	1101
97054	203500	28.5697	80.5864	6			66	61	1102
97054	203500	28.5697	80.5864	12	298	4.1			1102
97054	203500	28.5697	80.5864	54	345	16.9	65	60	1102
97054	203500	28.5697	80.5864	162	346	22.0			1102
97054	203500	28.5697	80.5864	204	343	22.9	63	59	1102
97054	203500	28.4843	80.7856	6					1204
97054	203500	28.4843	80.7856	54	5	12.1			1204
97054	203500	28.6445	80.9034	6					1215
97054	203500	28.4114	80.9284	6			72	71	1500
97054	203500	28.4114	80.9284	54	30	4.1			1500
97054	203500	28.4475	80.8538	6					1502
97054	203500	28.4960	80.8843	6					1605
97054	203500	28.4960	80.8843	54					1605
97054	203500	28.5583	80.9132	6					1609
97054	203500	28.6173	80.9581	6			68	60	1612

97054	203500	28.6173	80.9581	54	7	9.9			1612
97054	203500	28.6762	80.9987	6					1617
97054	203500	28.6762	80.9987	54					1617
97054	203500	28.5231	81.0100	6			70	60	2008
97054	203500	28.5231	81.0100	54	9	8.0			2008
97054	203500	28.6489	81.0693	6					2016
97054	203500	28.6489	81.0693	54					2016
97054	203500	28.4417	81.0291	6					2202
97054	203500	28.4417	81.0291	54					2202
97054	203500	28.6256	80.6571	6			65	60	3131
97054	203500	28.6256	80.6571	12	343	12.1			3131
97054	203500	28.6256	80.6571	54	346	18.1	64	60	3131
97054	203500	28.6256	80.6571	162	343	21.0			3131
97054	203500	28.6256	80.6571	204	344	21.0	63	60	3131
97054	203500	28.6256	80.6571	295	346	22.9			3131
97054	203500	28.6256	80.6571	394	342	25.1			3131
97054	203500	28.6256	80.6571	492	338	26.0	61	59	3131
97054	203500	28.6256	80.6571	6			65	59	3132
97054	203500	28.6256	80.6571	12	341	13.0			3132
97054	203500	28.6256	80.6571	54	349	19.1	64	59	3132
97054	203500	28.6256	80.6571	162	349	21.0			3132
97054	203500	28.6256	80.6571	204	354	22.0	63	59	3132
97054	203500	28.6256	80.6571	295	350	22.9			3132
97054	203500	28.6256	80.6571	394	352	26.0			3132
97054	203500	28.6256	80.6571	492	352	27.0	61	59	3132
97054	203500	28.3932	80.8211	6			70	61	9001
97054	203500	28.3932	80.8211	54	358	8.0			9001
97054	203500	28.3382	80.7321	6			71	63	9404
97054	203500	28.3382	80.7321	54	356	9.9			9404